



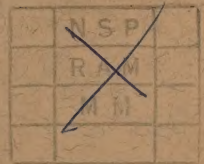
TECHNICAL REPORT

OF THE

CENTRAL RICE RESEARCH INSTITUTE

1958—1960

CUTTACK, INDIA 1961



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ORISSA

Weather and crop conditions.—The monsoon commenced in the last week of June in 1958, in the first week of June in the year 1959 and towards the end of May in the year 1960. The total precipitations during 1958, 1959 and 1960 were 1586.6 (62.47"), 1600.8 (63.04") and 1281.80 (50.48") mms. respectively. In the year 1958 the rainfall was evenly distributed except in the last week of November when it was far in excess due to which sowing of winter crops was considerably delayed. During the year 1959 the distribution of rainfall was uniform except in the first fortnight of October when it was far in excess of the normal due to which the harvest of the early varieties was delayed. The distribution of rainfall in mms. and in inches are given in the table I below :

TABLE I

Rainfall in mms. (inches) in 1958-60 as compared to the average of the last 10 years

Monsoon	Months	Normal rainfall (Average of 10 years)		Rainfall in 1958		Rainfall in 1959		Rainfall in 1960	
		mms	inches	mms	inches	mms	inches	mms	inches
Winter	January	9.9	0.39	30.7	1.21	23.7	0.93	0.0	0.00
	February	19.3	0.76	74.1	2.92	13.9	0.55	0.0	0.00
Pre-Monsoon	March	21.3	0.84	8.4	0.33	1.5	0.06	37.5	1.48
	April	23.9	0.94	1.8	0.07	85.2	3.36	7.3	0.29
	May	66.8	2.63	31.7	1.25	120.8	4.76	36.9	1.45
S. W. Monsoon	June	172.0	6.77	149.5	5.89	102.1	4.02	185.3	7.30
	July	247.9	9.76	335.3	13.20	326.8	12.87	455.7	17.94
	August	357.6	14.08	330.4	13.01	305.9	12.04	249.9	9.84
	September	309.6	12.19	290.6	11.44	150.9	5.94	216.1	8.51
Post-Monsoon	October	244.6	9.63	206.6	8.13	462.7	18.22	91.8	3.62
	November	72.4	2.85	127.5	5.02	0.0	0.00	0.0	0.00
	December	0.8	0.03	0.0	0.00	7.3	0.29	1.3	0.05
TOTAL		1546.1	60.87	1586.6	62.47	1600.8	63.04	1281.8	50.48

There was no severe attack of any pest and disease in all these three years but as a prophylactic measure the crops were sprayed with insecticides and fungicides. There was a mild outbreak of stem borer in the second crop season during the years 1958 and 1960.

Agronomy

1. *Varietal Trials* :

The yield performance of 156, 123 and 128 varieties grouped under different maturity periods were tested in six varietal trials in each of the years of 1958, 1959 and 1960 respectively. Besides 132, 112, and 125 types were grown in the main respective seasons under observation plot to determine their performance and for maintenance. In addition, varietal trials were conducted to study the suitability of rice varieties for drought conditions and for late planting following jute crop in the two years, 1958 and 1959. Two varietal trials were conducted in the second crop season (January-April 1959) one with 18 promising *indicas* and the other with three *indicas* and two *japonicas*, one Malayan and one Taiwan varieties. Besides 130 types were also grown with PTB-10 as control in observation plot during January-April to determine their suitability for the second crop season.

(i) *Early duration trials*.—Experiments were conducted with early varieties maturing within 100 days with N. 136 and CH. 2 as controls in the years 1958 and 1959 and only CH. 2 as control in the year 1960. Fifteen varieties were included in the trial in the years 1958 and 1959 while in the year 1960 only fourteen varieties were tested. The variety DCA-14 gave the highest grain yield of 3527 and 2600 Kg/Ha in the years 1958 and 1959 respectively. The variety CH. 45 recorded the highest yield of 3183, 1855 and 2261 Kg/Ha in the years 1958, 1959 and 1960 respectively and both the varieties *i.e.*, DCA-14 and CH. 45 were significantly superior to both the controls in the years under report.

In the trial of varieties maturing within 100-110 days 15 varieties were tested in 1958 and 1959 and twenty varieties in 1960 using *Benibhog* as the standard. The varieties PTB-10, CH-52, JBS-27 and BM No.5 were identical in yield performance with that of *Benibhog*, there being no significant difference among themselves.

In the trials of varieties maturing within 110-120 days BAM-12 was used as control in all the three years. In the year 1958 all the nineteen varieties tried gave significantly lower yield than the control BAM-12. In the year 1959 BAM-12 gave the highest yield of 2187 Kg/Ha which was statistically on par with the coarse varieties Co. 25×Co. 13-562-31-56-3-29, Co. 25×Co. 13-562-31-56-3-22, EHM-7-6-30-58 and EHM-42-76-95-2. Out of the eight superfine varieties EHF-170-322-22-42, PLA-1 and EHF-170-322-22-5 recorded 1719, 1587 and 1537 Kg/Ha of grain yields and were significantly superior to the control T. 608 with a grain yield of 1127 Kg/Ha. In the year 1960 highest grain yield was recorded by the cultures, EHM-7-13-43-95 and EHM-42-76-95-2 which gave 3098 and 2969 Kg/Ha respectively. The control BAM-12 yielded 2847 Kg/Ha. There were, however, no significant differences among the grain yields of the above mentioned three varieties. Rest of the varieties yielded lower than the control BAM-12.

(ii) *Mid-early varietal trials*.—In these trials hybrid cultures received from the Botany Division were tested with other varieties which matured within 120-130 days. The varieties T. 635 (coarse) and T. 608 (fine) were used as controls in all the three years under report. In the year 1958, 32 hybrid cultures were tested with 17 other varieties. Amongst coarse varieties one of the hybrid cultures *viz.*, EHM-42-72-48-9-39-42 yielded 2855 Kg/Ha which was significantly superior to the control T. 635 yielding 2231 Kg/Ha. PTB-13 and T. 442 also yielded significantly higher than the control. In the fine group six hybrid cultures gave 2.0 to 3.5 per cent higher yield than the control T. 608 which yielded 1809 Kg/Ha. In the year 1959 amongst 19 coarse grained cultures 18 cultures were found to be significantly superior to the control T. 635 which gave only 1426 Kg/Ha. In this group highest yield was recorded by EHM-170-319-92-138-196-26 which yielded 3152 Kg/Ha. The other two cultures *viz.*, EHM-196-346-8-69-64 and EHM-42-76-95-2-1-10 yielded 2526 and 2491 Kg/Ha respectively. The other cultures though yielded less than 2500 Kg/Ha, were significantly superior to the standard T. 635. Out of 8 superfine varieties 4 cultures *viz.*, $J \times I$ -197-79-168-72, $J \times I$ -599-10, EHF-161-303-73-46-68 and EHF-161-303-73-46-68-71 yielded 2717, 2694, 2539 and 2135 Kg/Ha of grain respectively and were significantly superior to the standard T. 608 (for fine grained varieties). In the year 1960, 22 hybrid cultures received from Botany Division and 10 other types were tried. Among 24 coarse varieties 2 hybrid cultures *viz.*, EHM-170-319-92-138-196-26 and EHM-112-241-2-57 recorded the grain yield of 3369 and 3175 Kg/Ha respectively which were significantly higher than that of control T. 635. During the year 1959 these 2 cultures gave 140 and 166 per cent higher yields than the same control. The other 2 varieties which gave significantly higher yield than the control were W. 449 and AC. 3997 with 3621 and 3156 Kg/Ha respectively. The control T. 635 yielded 2330 Kg/Ha. Among the eight fine grained types $J \times I$ -197-79-168-72, EHF-161-303-73-46-68, $J \times I$ -599-10 and EHF-161-363-73-34-66 recorded the grain yields of 2783, 2743, 2724 and 2334 Kg/Ha respectively which were significantly superior to control T. 608 which yielded 1674 Kg/Ha. In the year 1959 the above mentioned 4 cultures gave 164, 154, 163 and 110 per cent higher grain yield than the control T. 608.

(iii) *Medium duration trial*.—Varieties maturing within 130-145 days were tested in this group against popular varieties T. 141 and T. 1145 as control in all the three years under report. In the year 1958, 32 varieties were tested in this group in which T. 141-89, a secondary selection of T. 141 recorded the highest yield of 3450 Kg/Ha which was 2.2% more than the parent T. 141. Rest of the varieties were not significantly different in grain yield from that of T. 1145 the second control. In the year 1959 among 25 varieties tried, 2 varieties *viz.*, T. 378 (a variety from U.S.A.) and a hybrid culture (a cross between Norin-6 $\times$ GEB-24) $J \times I$ -431-32-23-17 evolved at Central Rice Research Institute recorded highest yield of 2507 Kg/Ha. Varieties $J \times I$ -679-28-64-38-12, FR-43-B, RDR-4, $J \times I$ -679-36-48-39 and T. 61 were statistically on par with the controls T. 141 and T. 1145 which yielded 1908 and 1709 Kg/Ha of grain yields respectively. In the year 1960 the varieties T. 61, $J \times I$ -679-28-64-38-12 and SLO-6 recorded the grain yields of 3626, 3602 and 3554 Kg/Ha respectively which were higher than that of both the controls.

(iv) *Late duration trial*.—Varieties maturing within 160 days were tried in this group with T. 1242 as the control. In the year 1959 all the varieties tried were statistically at par with the control which gave a grain yield of

1941 /KgHa. In 1960 varieties Co. 25 and PTB.18 yielded 2572 and 2563 Kg/Ha respectively while T. 1242 yielded 1995 Kg/Ha but the yield differences were not significant.

In the trial of varieties of over 170 days in duration 15 varieties were tried in the year 1958 with T. 1242 and T. 4450 as controls. Co-19 as in previous seven years recorded the highest yield of 3212 Kg/Ha which was 169 and 151 per cent higher than the controls T. 1242 and T. 4450 respectively.

(v) *Drought resistant varietal trial.*—To study the suitability of varieties for drought condition (grown under natural rainfed conditions) early duration varieties were tried with B. 76-1 as control in two out of three years under report. In the year 1958 out of 9 varieties tried the variety S-126 gave the highest yield of 2482 Kg/Ha which was 11.96 per cent higher than that of control yielding 2217 Kg/Ha but the differences were not statistically significant. In 1959 out of 10 varieties tried variety PTB. 10 yielded 2042 Kg/Ha which was statistically on par with B. 76-1.

(vi) *Late varietal trial following jute.*—In order to select rice varieties which can fit in a cropping pattern of rice following jute in irrigated areas varieties suitable for planting late in August or first week of September, were tried in varietal trials in two out of three years under report. In the year 1958 out of 10 varieties (4 medium and 6 late) the variety T. 1242 gave the highest yield of 2838 Kg/Ha followed by AC. 2732. The popular medium duration variety T. 141 yielded 2397 Kg/Ha. In 1959 the varieties T. 874-1-9-2, T. 588 and T. 1233 yielded 1889, 1845, and 1841 Kg/Ha respectively while T. 141 yielded 1608 Kg/Ha. The differences were however not found to be significant.

(vii) *Second season (Dalua) varietal trial.*—In the year 1959 in the second crop season between December and April, 18 promising dalua varieties from different states selected from earlier trials were grown with PTB-10 as control. MTU-15 gave the highest yield of 2941 Kg/Ha among all the varieties tried which was 27 per cent more than that of the control PTB-10 which yielded 2321 Kg/Ha. The varieties CH.65, MTU-9, Tepa-I, PLA-1, CH. 47 and Tkm. 6 gave 21.0, 20.0, 18.0, 17.4, 17.0 and 15.0 per cent higher yield than the control.

In another second season varietal trial with three *indicas*, two *japonicas*, one Malayan and one Taiwan varieties under 80 lb. nitrogen and 30 lbs. P_2O_5 per acre, highest yield of 2196 Kg/Ha. was obtained with MTU-15 followed by control PTB-10 with 2173 Kg/Ha. Norin-17 which did well during the previous season yielded 1345 Kg/Ha and BM No. 5 (Malayan) and Hsunchu (Taiwan) yielded 1840 and 2053 Kg/Ha respectively.

II. Variety $\times$ Manure Interaction :

To study the differential response of varieties grouped into three broad duration groups, *viz.*, early, medium and late to increasing levels of manures and their times of applications, field experiments were conducted during the three years under report.

During the year 1958, in the early varieties $\times$ manure interaction trial, 10 varieties (8 *indicas* and 2 *japonicas*) were tried at levels of 0, 30, 60 and 90 lb. N per acre with PTB-10 as control. The yield of grain obtained is presented in Table II below :

TABLE II

Yield of Grain in Kgm per hectare (lb/acre)

Name of variety	Control yield	Response in Kg/Ha at			Responses over control
		30 lb. N/A	60 lb. N/A	90 lb. N/A	
PTB. 10	1373 (1226)	230 (205)	44 (39)	147 (131)	100.00
MTU. 9	1920 (1715)	-170 (-152)	-314 (-281)	-438 (-392)	114.34
MTU. 15	1871 (1671)	-180 (-161)	-160 (-143)	-591 (-528)	110.83
B. 76-1	1794 (1602)	147 (131)	379 (339)	39 (34)	130.92
N. 136	1203 (1074)	173 (154)	224 (201)	292 (260)	93.03
EHF. 170-322-22-5 . . .	1657 (1480)	-5 (-5)	-312 (-279)	-369 (330)	100.54
EHM. 42-76-95-6 . . .	1812 (1618)	186 (166)	181 (161)	-72 (-65)	127.60
EHM. 7-13-43-95 . . .	1856 (1657)	-330 (-295)	294 (263)	-165 (-147)	133.36
Norin. 17	297 (265)	111 (99)	361 (323)	547 (489)	37.35
Norin. 18	289 (258)	34 (30)	78 (69)	181 (161)	24.49
MEAN	1407 (1257)				

1. C.D. (0.05) per hectare for variety means 150* (134)

2. C.D. (0.05) per hectare for Nitrogen means 243 (217)

3. C.D. (0.05) per hectare for variety means within a level of Nitrogen. 124* (110)

4. C.D. (0.05) per hectare for manure means within a variety . 307* (274)

N. B.—Figures in brackets indicate the yield in lb. per acre.

Though performance of the *japonicas* viz., Norin 17 and Norin 18 was poor and gave the lowest yield, they showed higher yield response with every increase in the level of N from 0 to 90 lb. N level. The differences in yield obtained at various levels of N were significant in case of Norin 17 and it was not so in Norin 18. All the *indica* varieties yielded maximum either at 0 or at 30 lb. N per acre. Beyond 30 lb. N the yield was very much depressed. The varieties MTU. 9, MTU. 15, B. 76-1, EHF. 170-322-22-5 and EHM. 7-13-43-95 showed significant differential response among *indica* varieties. The variety B. 76-1 has given significantly higher yield at 60 lb. N level over that of control.

Medium varieties × Nitrogen.—To study the differential response of various medium duration varieties of rice to increasing doses of nitrogen, 6 varieties (duration 120-145 days) were tried under 5 different levels of nitrogen i.e., 0, 20, 40, 60 and 80 lb. N per acre in a split plot design with levels of nitrogen in the main plot and varieties in sub-plots.

The varieties T. 635, PTB-13, EHM-112-241-2-68 and T. 141 were tried in all the three years under report. While T. 1879 and BAM. 9 × Norin-18 were tried in the year 1958, the varieties T. 1850 and 7 × I-148-76 were tried in subsequent two years i.e., 1959 and 1960. Significant differential response in one out of three experiments was obtained in the year 1958 and the yields of grain are presented in Table III below. :

TABLE III
Yield of Grain in Kgm per hectare (lb/per acre)

Variety	Control yield	Response in Kg/Ha at				Percentage over control
		20 lb. N	40 lb. N	60 lb. N	80 lb. N	
T. 635	1475 (1317)	301 (268)	362 (323)	397 (354)	255 (227)	69.35
PTB. 13	1820 (1625)	421 (376)	723 (645)	787 (702)	984 (878)	95.89
EHM.112-241-2-68	1186 (1059)	19 (17)	200 (178)	832 (742)	422 (377)	59.10
T. 141 (Control)	1898 (1695)	607 (542)	647 (577)	857 (765)	929 (829)	100.00
T. 1879	2289 (2044)	40 (36)	283 (252)	669 (597)	541 (483)	103.59
BAM. 9 × Norin.18	1515 (1352)	314 (280)	548 (490)	1142 (1020)	719 (642)	82.20
MEAN	1697 (1515)					

1. C.D. (0.05) per hectare for Nitrogen means 152* (136)
2. C.D.(0.05) per hectare for variety means 300* (268)
3. C.D.(0.05) per hectare for variety means within a level of Nitrogen. 670* (598)
4. G.D.(0.05) per hectare for Nitrogen means within a variety 630* (562)

In the year 1958 among the 6 varieties only in the case of T. 635 there was no significant difference in the grain yield between any two levels of nitrogen tried in the experiment. The varieties PTB. 13 and T. 141 gave progressively higher yields upto 80 lb. N per acre. The yields obtained with 40, 60 and 80 lb. N levels were significantly higher than that of the control yield, there being no significant difference between them. The varieties T. 635, EHM-112-241-2-68, T. 1879 and BAM. 9 × Norin 18 yielded their maximum at 60 lb. N per acre. The variety EHM-112-241-2-68 gave significantly higher yield beyond 40 lb. N level while rest of the varieties did not show significant difference in grain yield between the two levels of nitrogen *i.e.*, 40 lb. to 80 lb. tried in the experiment.

The variety × manure interaction was not significant in other two years 1959 and 1960.

Medium varieties × Nitrogen × Phosphorus.—Nine medium duration varieties *viz.* T. 141, Bk. 6, T. 1233, BAM. 9 × Norin. 18, T. 90 × Aikoku, T. 874-1-9-2, T. 588, BR-6 and J × I-43-1 were tried during the course of three years under report with eight treatment combinations of nitrogen and phosphorus (or 30, 60 and 90 lb. N/acre × 0 and 50 lb. P₂O₅/acre) to study the differential response of the varieties. The entire dose of P₂O₅ was applied at the time of planting whereas nitrogen was applied in two splits, one half at the time of planting and the other half was applied two weeks before flowering. Significant differential response was obtained in two out of three years under report and the data are presented in Tables IV(a), IV(b) and IV(c) and V(a), V(b) and V(c).

TABLE IV(a)
Yield of Grain in Kg/Hectare (lb/acre)

Variety	Control yield	Response in Kg/Ha at			Percentage over control
		N 30/A	N 60/A	N 90/A	
T. 141	2705 (2415)	529 (473)	901 (805)	—85 (—76)	100.00
BK. 6	2714 (2423)	174 (156)	465 (415)	31 (28)	94.73
T. 1233	2672 (2386)	488 (435)	338 (302)	—133 (—119)	93.55
BAM. 9 × Norin. 18	2721 (2429)	106 (95)	125 (112)	—282 (—251)	89.05
T. 90 × Aikoku	2503 (2235)	159 (142)	—305 (—272)	—467 (—417)	77.28
T. 874-1-9-2	2937 (2622)	—180 (—160)	350 (313)	—408 (—364)	94.61
MEAN	2708 (2418)				

C.D. (0.05) for N means 382.83* (341.82)
 C.D. (0.05) for variety means 176.60* (157.68)
 C.D. (0.05) for variety means within a level of N. 353.20* (315.36)
 C.D. (0.05) for N means within a variety 487.42* (435.19)

TABLE IV (b)

Field of Grain in Kgm/Hectare

Year 1958

Variety	P ₀	Response at 50 lb. P ₂ O ₅ /A	Percentage over control
T. 141	3001 (2679)	80 (72)	100.00
BK. 6	2905 (2594)	-48 (-43)	94.73
T. 1233	2823 (2521)	44 (39)	93.55
BAM. 9 × Norin. 18	2685 (2397)	46 (41)	89.03
T. 90 × Aikoku	2350 (2098)	-1 (-1)	77.28
T 874-1-9-2	2768 (2471)	219 (196)	94.61
MEAN	2755 (2460)		

TABLE IV (c)

Field of Grain in Kgm/Hectare

Year 1958

N	N ₀	N ₃₀	N ₆₀	N ₉₀	Mean
P					
P ₀	2735 (2442)	2901 (2590)	3011 (2688)	2375 (2121)	2756 (2461)
P ₃₀	2682 (2395)	2941 (2626)	3030 (2705)	2594 (2316)	2812 (2511)
MEAN	2708 (2418)	2921 (2680)	3021 (2697)	2485 (2219)	

Increased yield was obtained with increase in level of N upto 60 lb. N/acre in all the varieties except in T. 1233 and T. 90×Aikoku which yielded maximum at 30 lb. N level. In the last named variety there was significant decrease in yield at 60 lb. N level over that of 30 lb. N level. At 90 lb. N/acre all the varieties yielded less than that of 60 lb. N dose. There was significant difference in varietal response within a level of N. At No, variety T 874-1-9-2 gave the highest yield which was significantly superior to T. 90×Aikoku while, at 30 and 60 lb. N levels T. 141 gave the highest yield. The varieties T.141, T. 1233, T. 90×Aikoku and T. 874-1-9-2 gave significant differential response, while BK 6 and BAM.9×Norin 18 did not exhibit any interaction with Nitrogen. There was, however, no interaction between varieties and levels of PO_{52} .

The yields of grain obtained during the year 1959 are presented in the tables V(a), V(b) and V(c) below.

TABLE V (a)
Yield of Grain in Kg/Ha (lb/acre)

Year 1959

Varieties	Na		N ₃₀		N ₆₀		N ₉₀		Mean
	P ₀	P ₅₀	P ₀	P ₅₀	P ₀	P ₅₀	P ₀	P ₅₀	
T. 141	1811 (1617)	1466 (1309)	2593 (2315)	2548 (2275)	3203 (2860)	3145 (2808)	3137 (2801)	2419 (2156)	2550 (2268)
Bk. 6	1185 (1058)	1104 (986)	1885 (1683)	1598 (1427)	1738 (1552)	1709 (156)	1598 (1427)	2283 (2038)	1638 (1463)
T.1233	1754 (1566)	180 (1625)	2548 (2275)	2326 (2077)	2887 (2578)	2880 (2571)	3255 (2960)	1222 (1091)	2337 (2087)
T.874-1-9-2	1832 (1636)	1547 (1381)	2501 (2590)	2210 (1973)	3270 (290)	2872 (2564)	3019 (2696)	3138 (2802)	2599 (2321)
T.588	1938 (1730)	1907 (1703)	2751 (2459)	2681 (2394)	3023 (2696)	2770 (2473)	3121 (2787)	2489 (2222)	2585 (2308)
BR6	988 (882)	1149 (1026)	1818 (1650)	1501 (1340)	1916 (1711)	1723 (1538)	1915 (1710)	1695 (1513)	1592 (1421)
MEAN	1585 (1415)	1499 (1338)	2422 (2168)	2144 (1914)	2673 (2387)	2517 (2247)	2674 (2388)	2207 (1971)	..

TABLE V (b)

Yield of Grain in Kg/Ha (lb/acre)

Year 1959

Varieties	Levels of N in lb/A				
	N ₀	N ₃₀	N ₆₀	N ₉₀	Mean
T. 141	1639 (1463)	2571 (2296)	3174 (2834)	2776 (2479)	2540 (2268)
Bk. 6	1145 (1022)	1742 (1555)	1724 (1539)	1941 (1733)	1638 (1463)
T. 1233	1787 (1596)	2437 (2176)	2884 (2575)	2239 (1999)	2337 (2087)
T. 874-1-9-2	1690 (1509)	2556 (2282)	3071 (2742)	3079 (2749)	2599 (2321)
T. 588	1923 (1717)	2718 (2427)	2897 (2587)	2805 (2504)	2585 (2308)
BR. 6	1069 (954)	1675 (1496)	1820 (1625)	1805 (1612)	1592 (1421)
MEAN	1542 (1377)	2283 (2038)	2595 (2317)	2441 (2179)	

S. E. of N means = ± 81.08 (± 72.39)

C. D. (0.05) per hectare for comparing N means = 271.03 (241.99)**

S. E. of variety means = ± 64.58 (± 57.66)

C. D. (0.05) per hectare for comparing variety means = 184.53 (164.76)**

S. E. of variety means within a level of N = ± 129.16 (± 115.32)C. D. (0.05) per hectare to compare variety means within a level of N = ± 370.03 (330.38)**S. E. of N means within a variety = ± 143.49 (± 127.94)

C. D. (0.05) per hectare to compare N means within a variety = 431.30 (385.09)*

TABLE V (c)

Yield of Grain in Kg/Ha (lb/acre)

Year 1959

Varieties	P ₀	P ₅₀	Mean
T. 141	2686 (2398)	2394 (2138)	2540 (2268)
Bk. 6	1602 (1430)	1674 (1495)	1638 (1463)
T. 1233	2611 (2331)	2062 (1841)	2337 (2087)
T. 874-1-9-2	2756 (2461)	2442 (2180)	2599 (2321)
T. 588	2709 (2419)	2462 (2198)	2585 (2308)
BR. 6	1667 (1488)	1517 (1354)	1592 (1421)
MEAN	2339 (2088)	2092 (1868)	

S. E. of P means = ± 54.94 (± 49.03)

C. D. (0.05) per hectare to compare P means = 191.51 (170.99)*

S. E. of variety means within same level of P = ± 91.45 (± 81.65)

C. D. (0.05) per hectare to compare variety means within same level of P = 261.61 (233.58)*

S. E. of P means within a variety = ± 101.34 (± 90.48)

C. D. (0.05) per hectare to compare P means within a variety = 305.21 (272.51)*

The variety $\times$ N interaction was significant. Variety T. 588 produced the highest yield at N₀ and N₃₀ levels which was significantly superior to the yield of BR. 6 and BK. 6. At N₆₀ level T. 141 gave the highest yield of 3174 Kg/Ha (2834 lb/A) which was significantly superior to the yield of BK. 6 and BR. 6. At N₉₀ level, the variety T. 874-1-9-2 recorded the highest yield of 3079 Kg/Ha which was significantly superior to BR.6, BK. 6 and T. 1233.

The variety $\times$ P interaction was significant. At P₀ T. 874-1-9-2 gave the highest yield of 2756 Kg/Ha while at the levels of 50 lb P₂O₅/A the variety T. 588 gave the highest yield. At 50 lb. level of P₂O₅ the variety. T. 588 gave the highest yield.

Among four levels of N tried *i.e.* 0, 30, 60 and 90 lb. N/A, the highest yield was obtained with N₆₀. Both the levels of N *i.e.* N₆₀ and N₉₀ were significantly superior to the N₀ and N₃₀ levels. Control plot gave the lowest yield of 1542 Kg/Ha.

During the year 1960 interactions between varieties $\times$ nitrogen and between varieties $\times$ P_2O_5 were not significant.

Late varieties $\times$ Nitrogen—To study the differential response of late duration varieties (160 days and above) to different levels of nitrogen 24 varieties were tested during the three years under report. The experiments were conducted in a split plot design with levels of nitrogen in the main plot and varieties in the sub-plot. Significant differential response was obtained in one out of the three experiments. The grain yield data of the year 1958 are presented in the table VI below :

TABLE VI
Yield of grain in Kg/Ha (lb per acre)

Year 1958					
Variety	Control yield	Response in Kg/Ha at		Mean yield in Kg/Ha	Percentage on control
		N 30/A	N 60/A		
T. 1242 . . .	1476 (1318)	603 (538)	716 (639)	1915 (1710)	100.00
BAM. 9 . . .	1728 (1543)	19 (17)	111 (99)	1772 (1582)	92.53
T.90 . . .	1394 (1245)	376 (335)	221 (197)	1615 (1442)	84.33
AC. 2589 . . .	1070 (955)	1087 (971)	290 (259)	1529 (1365)	79.84
AC. 2732 . . .	1063 (949)	662 (591)	9 (8)	1287 (1149)	67.21
AC. 3051 . . .	1280 (1143)	82 (73)	-287 (-256)	1212 (1082)	63.28
Tripple cross . . .	1334 (1191)	622 (555)	193 (172)	1605 (1433)	83.81
S.R. 26. B . . .	811 (724)	688 (614)	615 (549)	1245 (1112)	65.01
S. 67 . . .	933 (833)	583 (521)	-103 (-92)	1093 (976)	57.08
MTU. 19 . . .	1192 (1064)	344 (307)	-51 (-45)	1289 (1151)	67.31
SLO. 14 . . .	1280 (1143)	281 (251)	104 (93)	1409 (1258)	73.58
CR. 4-10 . . .	1256 (1121)	397 (355)	135 (121)	1434 (1280)	74.88
T.109-a . . .	981 (876)	473 (422)	164 (146)	1193 (1065)	62.30
T. 2059 . . .	902 (805)	649 (580)	347 (310)	1234 (1102)	64.44

TABLE VI—*contd.*

Variety	Control yield	Response in Kg/Ha at		Mean yield in Kg/Ha	Percentage on control
		N 30/A	N 60/A		
EC. 2705	1381 (1233)	719 (642)	240 (224)	1700 (1518)	88.77
T. 498-2a	820 (741)	—51 (—45)	85 (67)	834 (745)	43.55
MTU. 16	788 (704)	395 (352)	133 (118)	964 (861)	50.34
C. 30-28	886 (791)	594 (530)	259 (231)	1170 (1045)	61.10
AKP. 4	788 (704)	763 (681)	—34 (—31)	1032 (921)	53.89
AC. 1951	716 (639)	375 (335)	271 (242)	931 (831)	48.62
BAM. 6	1353 (1208)	467 (417)	495 (442)	1673 (1474)	87.36
MTU. 21	1192 (1064)	486 (434)	—101 (—90)	1320 (1179)	68.93
T. 4450	1280 (1143)	537 (479)	—69 (—62)	1436 (1282)	74.99
PTB. 16	332 (296)	1053 (932)	687 (614)	908 (811)	47.42
MEAN	1093 (976)				

C. D. (0.05) for N means 299.49* (264.70)

C. D. (0.05) for variety means 197.75* (176.56)

C. D. (0.05) for variety means within a level of N 342.21** (305.54)

C. D. (0.05) for N means within a variety 443.44** (395.93)

Varieties T. 1242, AC. 2589, AC. 2732, Tripple cross, SR. 26B, S. 67, T. 109-a, EC 2705, C 30-28, AKP. 4, AC. 1951, BAM. 6, MTU. 21, T. 4450 and PTB. 16 gave significantly higher yield at 30 lb. N level over that of control. Varieties BAM. 9, T. 90, AC. 3051, MTU. 19, SLO. 14, T. 498-2a and MTU. 16 did not give any differential response at various levels of N.

Late varieties × times of application of Nitrogen.—To find out the differential response of late duration varieties of rice to various times of application of Nitrogen, six varieties namely T. 1242, BAM. 9, Akp. 4, CR-4-10, PTB. 16 and Ac. 1951 were tried with T. 1242 as local standard during the three years under report. A dose of 40 lb. N per acre in the form of Sulphate of ammonia was applied (1) at planting (P), (2) one month after planting (T), (3) one month before flowering (F) in single doses, (4) half at planting half one

month after planting (PT), (5) Half at planting half one month before flowering (PF), (6) half one month after planting plus half one month before flowering (TF) in two splits, (7) one third at planting plus one third one month after planting plus one third one month before flowering (PTF) in three splits with one (8) unmanured control. The experiments were conducted in split plot design with times of application in the main plot and varieties in the sub-plot in four replications.

The results indicated that the application of fertilizer in two split doses one at the time of planting and the other one month before flowering gave the highest grain yield followed immediately by the single dose application one month before flowering, there being no significant difference between the two. Single dose application of nitrogen at the time of planting gave the lowest yield among all the treatments and there was no significant difference between the control yield and that of the single dose application at planting time.

There was no interaction between the times of application of nitrogen and the varieties tried in all the three years.

III. Manurial Trials :

Efficiency of nitrogenous fertilizers.—Experiments were conducted to test the relative efficiency of 9 forms of different nitrogenous fertilizers in the year 1958 while ten forms including some of newer fertilizers like Urea Formaldehyde, Nitrophoska green and Nitrophoska blue were tried during the subsequent two years under report. The fertilizers were applied at 30 and 60 lb. N per acre, one half at the time of planting and the other half one month before flowering as pellets. The yields obtained with various nitrogenous fertilizers are given in the Table VII(a) and VII(b) below:

TABLE VII (a)

Yield of rice in Kg/Ha (lb/acre) for various forms of nitrogenous fertilizers

Variety-T. 141

Year 1958

Sl. No.	Fertilizers	Levels of N/A		Mean	Percentage over control	Percentage over Ammonium Sulphate
		30 lb.	60 lb.			
1	Amm. Sulphate . .	3219 (2874)	3714 (3316)	3466 (3095)	166.7	100.0
2	Amm. Chloride . .	3235 (2888)	3634 (3245)	3435 (3067)	165.2	99.1
3	Amm. Phosphate . .	3288 (2936)	3745 (3344)	3517 (3140)	169.1	101.5

TABLE VII (a)—*contd.*

Sl. No.	Fertilizers	Levels of N/A		Mean	Percentage over control	Percentage over Ammonium Sulphate
		30 lb.	60 b.			
4	Amm. Nitrate.	2781 (2483)	3333 (2976)	3058 (2730)	147.0	88.2
5	Amm. Sulphate-nitrate . .	2923 (2610)	3688 (3293)	3306 (2952)	158.9	95.4
6	Calcium Ammonium nitrate	2873 (2565)	3221 (2876)	3048 (2721)	146.5	87.9
7	Urea	3345 (2987)	3564 (3182)	3455 (3085)	166.1	99.7
8	Sodium Nitrate	2801 (2501)	2692 (2404)	2747 (2453)	132.1	79.3
9	Complezal	2939 (2624)	3195 (2853)	3070 (2741)	147.6	88.6
10	Control I (No manure) . .			2080 (1857)	100.0	60.0
11	Control II (60 lb. P_2O_5) . .			2353 (2101)	113.1	67.9
	MEAN	3045 (2719)	3422 (3055)	3233 (2887)		

C. D. (0.05) to compare level means 100 (89)

C. D. (0.05) to compare fertilizer means 212 (189)

C. D. (0.05) to compare individual treatments 300 (268)

In the year 1958 all the fertilizers gave significantly higher yield response over that of no manure control and the yield increase showed a linear trend upto a dose of 60 lb. N per acre. The responses obtained with Ammonium Phosphate, Ammonium Sulphate, Urea, Ammonium Chloride and Ammonium Sulphate Nitrate were 169.1, 166.7, 166.1, 165.2 and 158.9 per cent higher over that of no manure control respectively. The fertilizers, Ammonium Nitrate, Calcium Ammonium Nitrate and Sodium Nitrate were significantly inferior to Ammonium Sulphate. A complex fertilizer Complezal which was included in the trial for the first time was found to be inferior to ammonium sulphate.

The grain yield data of the years 1959 and 1960 are given in table VII (b) below :

TABLE VII (b)
Yield of grain in Kg/Ha

Sl. No.	Fertilizers	Year 1959				Year 1960			
		Level of nitrogen		Mean	% over control	Level of nitrogen		Mean	% over control
		30 lb. N/Ac	60 lb. N/Ac			30 lb. N/Ac	60 lb. N/Ac		
1.	Ammonium Phosphate	2522	3349	2935	176.38	3276	3066	3171	119.40
2.	Ammonium Chloride	2513	3124	2819	169.38	3152	3310	3231	121.60
3.	Ammonium Sulphate	2536	3098	2817	169.25	2903	2829	2866	107.90
4.	Ammonium Sulphate Nitrate.	2439	2803	2621	157.54	3256	3213	3235	121.70
5.	Calcium Ammonium Nitrate.	2376	2565	2470	148.45	3012	3059	3036	114.30
6.	Urea	2335	2576	2456	147.58	3256	3025	3141	118.30
7.	Nitrophoska Blue .	2201	2561	2381	143.06	2774	3351	3063	115.30
8.	Nitrophoska Green .	2207	2312	2159	129.74	2978	2869	2924	110.10
9.	Complezal . . .	2022	2234	2128	127.86	2896	2964	2930	110.30
10.	Urea Formaldehyde .	2038	2004	2021	121.47	2869	3331	3100	116.70
11.	Control (no manure)			1664	100.00			2656	100.00
	MEAN . .	2337	2733			3029	3120		

S. E. for level of N means = ± 48.6 Kg/Ha
 C. D. (0.05) to compare level of N = 139. Kg. /Ha.
 S. E. for fertilizer means = ± 119.0 Kg./Ha.
 C. D. (0.05) to compare fertilizers = 339 Kg/Ha.
 S. E. for individuals treatment means = ± 169 Kg/Ha
 C. D. to compare individual treatment = 479 Kg/Ha

} For 1959

S. E. for level of N means = ± 36.1 Kg/Ha
 C. D. (0.05) to compare level of N = 102.4 Kg/Ha
 S. E. for fertilizer means = ± 88.3 Kg/Ha
 C. D. (0.05) to compare fertilizers = 250.7 Kg/Ha
 S. E. for individual treatment means = ± 125.0 Kg/Ha
 C. D. (0.05) to compare individual treatment = 354.7 Kg/Ha

} For 1960

In the year 1959 all the fertilizers gave significantly higher yield than that of no manure control and the yield increase showed a linear trend up to a dose of 60 lb. N/A. The average responses obtained with Ammonium Phosphate, Ammonium Sulphate, and Ammonium Chloride were 76.38, 69.25 and 69.38% higher over that of no manure control respectively. The fertilizers Calcium-Ammonium nitrate, Urea, Urea formaldehyde, Complestal, Nitrophoska green and Nitrophoska blue were significantly inferior to Ammonium sulphate. The relative ratings of Ammonium phosphate, Ammonium chloride, Ammonium sulphate nitrate, Calcium-Ammonium nitrate, Urea, Nitrophoska blue, Nitrophoska green, Complestal and Urea formaldehyde are 104.19, 100.00, 93.04, 87.68, 87.18, 84.52, 76.64, 75.54 and 71.74 respectively taking Ammonium Sulphate as 100.00.

In the year 1960 all the fertilizers except Ammonium sulphate gave significantly higher yield over that of no manure control. So far the level of N was concerned the yield obtained at 60 lb. N per acre was higher than that of 30 lb. N, but the differences were not statistically significant. The level of 30 lb. N per acre however gave significantly higher yield over no manure control. The responses obtained with Ammonium sulphate—nitrate, Ammonium Chloride, Ammonium Phosphate, Urea and Urea Formaldehyde were 21.7, 21.6, 19.4, 18.3 and 16.7 per cent higher respectively over that of no manure control.

Placement of different forms of nitrogenous fertilizers.—To assess the efficiency of single and fractional sub-surface application of different forms of nitrogenous fertilizers field experiments were conducted during the three years under report. The fertilizers tried were Ammonium Sulphate, Calcium Ammonium Nitrate and Complestal. A long duration variety T. 1242 (160 days) was grown in the experiment. The average yield responses obtained with different treatments are presented below in Table VIII(a), VIII(b) and VIII(c).

TABLE VIII(a)
Yield of grain in Kg/Ha

(Average of 3 years, 1958-60)

Method	Fertilizers			Mean
	Ammonium Sulphate	Calcium Ammonium nitrate	Complestal	
Surface application	1850	1931	1862	1881
Sub-surface application (average of all splits)	2280	2004	1916	206
Control (no manure)	..	..	..	1538

The results show that sub-surface application increased the yield by 186 Kg/Ha over the corresponding surface application.

TABLE VIII(b)

Response in Kg/Ha over no-manure control

(Average of 3 years, 1958-60)

Method	Fertilizers			Mean
	Ammonium sulphate	Calcium-Ammonium-nitrate	Complelal	
Surface application	312	393	324	343
Sub-surface application	742	666	378	595

It would be seen from the table above that while the increase in yield due to sub-surface application over surface application was 430 and 273 Kg/Ha Ammonium Sulphate and Calcium Ammonium Nitrate respectively, it was only 54 Kg/Ha in case of Complelal which showed that the efficiency of both Ammonium Sulphate and Calcium Ammonium Nitrate could be considerably increased by sub-surface application.

TABLE VIII(c)

Response in Kg/Ha over no-manure control

(Average of 3 years, 1958-60)

Method	Fertilizers			Mean
	Ammonium sulphate	Calcium Ammonium nitrate	Complelal	
(A) Surface application	312	393	323	343
(B) Sub-surface application--				
1. in one dose	651	357	311	440
2. in two doses	732	442	374	516
3. in three splits	843	599	449	630

The result showed that there was a linear trend of increase in yield response by sub-surface application in split doses *viz.* single, double and three split application all of which gave higher yield than that of single dose surface application. The results further showed that efficiency of Ammonium Sulphate could be considerably increased by application of fertilizers in three split doses.

Optimum time and level of application of phosphatic fertilizers.—In the earlier trials application of phosphatic fertilizers in increasing levels did not show any effect. Hence it was thought necessary to study whether various times of application of phosphatic fertilizer have any effect on the yield of rice. Accordingly a field experiment was initiated during the year 1958 to determine the optimum time and level of P_2O_5 /acre. Single superphosphate @ 30, 60 and 90 lb P_2O_5 /acre was applied at the time of planting, one month after planting, one month before flowering and a week after flowering. Two extra treatments, 30 lb.N/Acre as Ammonium Sulphate and no manure control were also included in the experiment.

The result showed that different times and levels of P_2O_5 application in the form of single superphosphate did not affect the yield of the crop as there was no significant difference among various P_2O_5 treatments. Application of 30 lb. N/acre as Sulphate of ammonia significantly increased the yield of the crop as compare to that of no manure control.

Long range manurial experiments.—These experiments, as previously reported, are designed to investigate the cumulative effect of continuous application of various fertilizers and manures on the condition and productivity of rice soils.

(i) *Ammonium sulphate with and without lime and compost.*—This experiment has been in progress for the last thirteen years to study whether the continuous application of Ammonium sulphate in varying doses has any deleterious effect on the soil productivity and if so, whether it can be counteracted by the application of organic matter like compost and a soil ameliorant like lime. Ammonium sulphate at 0, 20 and 40 lb. N per acre is being applied every year on the same plots with and without 100 mds. of compost as the basal dressing. Lime is applied once in three years at 0, 4 and 8 cwt. per acre. The average grain yield data of three years (1958-60) are presented in following Tables IX(a) and IX(b):

TABLE IX(a)
Yield of grain in Kg/Ha
Variety-T. 1145 (145 days duration)
(Average of 3 years 1958-60)

Basal dressing of Lime in CWT per acre	No compost				Compost at 100 mds/Acre			
	N ₀	N ₂₀	N ₄₀	Mean	N ₀	N ₂₀	N ₄₀	Mean
L ₀ . .	2027	2455	2720	2400	2544	2855	2728	2709
L ₄ . .	1964	2360	2720	2348	2524	2860	2795	2726
L ₈ . .	2027	2443	2825	2432	2645	2865	2823	2777
MEAN	2006	2419	2755	2394	2571	2860	2782	2738

It would be seen from the data presented in the table IX(a) that compost @ 100 mds. per acre gave an yield of 2738 Kg/Ha as against 2394 Kg/Ha in no-compost plots. Both the levels of nitrogen i.e. N₂₀ and N₄₀ gave significantly higher yields over no manure control. Maximum yield of 2860 Kg/Ha was obtained when 20 lb. N per acre was superimposed over 100 mds. of compost (averaged over lime treatment).

TABLE IX(b)
Yield of grain in Kg/Ha averaged over compost treatment
(Average of 3 years)

	N ₀	N ₂₀	N ₄₀	Mean
L ₀	2286	2655	2724	2555
L ₄	2244	2610	2758	2537
L ₈	2336	2654	2824	2605
MEAN	2289	2640	2769	2566

The differences in grain yield due to lime application were not significant. This indicates that thirteen years of continuous application of sulphate of ammonia either alone or in combination with 100 mds. of compost did not bring about any deterioration of soil condition necessitating lime application.

(ii) *Ammonium sulphate with and without compost.*—The experiment was conducted for the twelfth year in succession on the same site. The results are given yearwise in table X(a) below :

TABLE X(a)
Yield of grain in Kg/Ha
Variety-T. 1145

Top dressing of Ammonium sulphate	Year 1958			Year 1959			Year 1960		
	Basal dressing of compost in mds.			Basal dressing of Compost in mds.			Basal dressing of compost in mds.		
	C ₀	C ₁₀₀	Mean	C ₀	C ₁₀₀	Mean	C ₀	C ₁₀₀	Mean
N ₀	2083	257	2331	1919	2423	2171	2069	2572	2321
N ₂₀	2552	2902	2727	2306	2888	2597	2332	2406	2369
N ₄₀	2731	2703	2717	2783	2625	2704	2341	1925	2133
N ₆₀	2684	2069	2377	2965	2565	2765	2345	1960	2153
N ₈₀	2382	1957	2171	2947	1669	2308	2014	1159	1586
MEAN	2487	2444	..	2584	2434	..	2220	2004	..

C. D. (0.05) for comparing compost means. = 130 Kg/Ha . . . 254 Kg/Ha . . . 221 Kg/Ha
 C. D. (0.05) for comparing N means = 87 Kg/Ha . . . 317 Kg/Ha . . . 226 Kg/Ha
 C. D. (0.05) for comparing compost means at the same level of N. = 67 Kg/Ha . . . 374 Kg/Ha . . . 354 Kg/Ha
 C. D. (0.05) for comparing N means at the same level of compost. = 124 Kg/Ha (1958) . . . 448 Kg/Ha (1959) . . . 320 Kg/Ha (1960)

In the year 1958 the effect of ammonium sulphate was significant and also its interaction with basal dressing of compost. In the case of sulphate of ammonia applied alone there was a significant yield increase upto 40 lb. N per acre while when applied over a basal dressing of compost, the yield increased significantly only upto 40 lb. N per acre. In the year 1959 compost application did not give any significant increase in grain yield over that of no-compost treatment. The differences in grain yield due to various levels of nitrogen was highly significant. The levels of 20, 40 and 60 lb. N per acre gave significantly higher grain yield over N_0 while the difference between N_0 and N_{80} was not statistically significant. The interaction between compost and levels of nitrogen was also significant. In the no-compost series significant increase in grain yield was obtained upto 40 lb. N per acre. In the compost plot maximum yield of 2888 Kg/Ha was obtained at N_{20} level. With higher levels of N there was a depression in yield. In the year 1960 among all the levels of nitrogen N_{20} gave the highest yield of 2369 Kg/Ha which was significantly higher than N_{40} and N_{80} levels. The differences in grain yield between the N_0 and rest of the three levels i.e. N_{20} , N_{40} and N_{60} were, however, not significant. There was a trend of decrease in grain yield with every increase in the level of nitrogen beyond 20 lb. N dose. At the maximum dose of 80 lb. N per acre the yield was least i.e. 1586 Kg/Ha which was significantly lower than rest of the levels of N including the control treatment. In the no-compost series the levels of 20, 40 and 60 lb. N per acre gave identical yields while at the highest dose i.e. 80 lb. N per acre the yield decreased significantly. In the compost series, maximum yield 2572 Kg/Ha was obtained at 0 lb. N per acre. The yield decreased significantly with every increase in the level of N, reaching the minimum at the highest dose. It is very interesting to note that compost application @ 100 mds. per acre gave the highest yield of 2572 Kg/Ha which was not touched by any other dose of N tried in the experiment.

The yield—N relationship could be represented by the quadratic curve as given by the equations.

$$\begin{array}{l}
 1958 \left\{ \begin{array}{l} \text{No compost } Y = 1864.44 + 25.79x - 0.28x^2 \\ \text{Compost } Y = 2384.49 + 7.39x - 0.21x^2 \end{array} \right. \\
 1959 \left\{ \begin{array}{l} \text{No compost } Y = 1681.06 + 26.23x - 0.18x^2 \\ \text{Compost } Y = 2180.21 + 23.8x - 0.40x^2 \end{array} \right.
 \end{array}$$

where 'Y' is the expected yield in lb. per acre and x is the level of N. From the yield-N quadratic function, the estimated maximum yield of 2450 lb. per acre (2744 Kg/Ha) and 2455 lb. per acre (2750 Kg/Ha) were obtained with 18 lb. N per acre and 46 lb. N per acre in the form of Ammonium sulphate with and without compost respectively in the year 1958 while during 1959 the estimated maximum yield of 2535 lb. per acre (2839 Kg/Ha) and 2637 lb. per acre (2953 Kg/Ha) were obtained with 30 lb. N per acre and 73 lb. N per acre in the form of Ammonium sulphate with and without compost respectively.

Residual effect.—To Study the residual and cumulative effect of Ammonium sulphate and compost applied continuously for eight years in the study mentioned above, each of the plots was divided into two equal halves and compost

and Ammonium sulphate were applied only to one half of the plots scheduled to receive the treatments. The results are given in the Table X(b) below:

TABLE X(b)

Study of the cumulative residual effect of Ammonium Sulphate and compost

Yield of grain in Kg/Ha

Level of N as Ammonium Sulphate	1958			1959			1960		
	C ₀	C ₁₀₀	C ₁₀ - C ₀	C ₀	C ₁₀₀	C ₁₀₀ - C ₀	C ₀	C ₁₀₀	C ₁₀₀ - C ₀
N ₀ . . .	2152	2510	358	1845	2119	274	2093	2531	438
N ₂₀ . . .	2122	2504	382	1751	2152	401	2038	2511	473
N ₄₀ . . .	2134	2483	349	1897	2047	150	2032	2484	452
N ₆₀ . . .	2055	2520	465	1821	2177	356	2009	2417	408
N ₈₀ . . .	2091	2538	447	1892	2024	132	2120	2503	383
MEAN .	2110	2510	400	1841	2104	262	2058	2489	431

It might be seen from the table above that there were no residual effects in the case of Ammonium sulphate in all the three years 1958, 1959 and 1960 but the crop in the plots where compost was applied in the previous years showed a cumulative effect and in the second, third and fourth year of study there were increases of 400, 262 and 431 Kg/Ha of paddy as compared to the no compost treatment and these differences were found to be significant. Continuous application of Ammonium sulphate did not give any beneficial or deleterious residuary effect.

(iii) *N. P. K. Experiment.*—This experiment is designed to find a suitable combination of the major plant nutrients N, P and K when applied alone and in conjunction with compost. Ammonium sulphate was applied at 0, 40 and 80 lb. N/A, Superphosphate at 0, 50 and 100 lb. P₂O₅/Ac and Potassium

sulphate at 0, 30 and 60 lb. K_2O/Ac . The basal dressing of compost was made at 20 lb N/Ac. The yield data are given in Table XI(a) and (b) below :

TABLE XI(a)
Yield of grain in Kg/Ha
Variety T. 1145

(145 days duration)

/Compost	Year 1958			Year 1959			Year 1960		
	No ma-nure	Com-post	Mean	No ma-nure	Com-post	Mean	No ma-nure	Com-post	Mean
N ₀ . . .	1876	2042	1959	1702	1988	1845	1684	1600	1642
N ₄₀ . . .	2328	2234	2281	2377	2352	2365	1996	1901	1949
N ₈₀ . . .	2316	2302	2309	2506	2510	2508	2087	2181	2134
MEAN ..	2174	2193	..	2195	2283	..	1922	1894	..

C. D. (0.05) for comparing N, P or K means = 95 Kg/Ha 155 Kg/Ha 109 Kg/Ha
Years (1958) (1959) 1960

TABLE XI(b)
Yield of grain in Kg/Ha

(Average of 3 years 1958, 1959 and 1960)

	0	K ₈₀	K ₆₀	Mean
P ₀	2093	2051	2143	2096
P ₆₀	2090	2064	2174	2110
P ₁₀₀	2123	2129	2124	2126
MEAN ..	2102	2081	2147	..

In the year 1958 the N and N × compost interactions were significant when applied alone or over a basal dressing of compost supplying 20 lb. N per acre. There was no significant increase between 40 lb. N and 80 lb. N levels but both of them gave a significant increase over No treatment. Similar observations were made in the year 1959. In the year 1960 application of N in the form of sulphate of Ammonia increased the yield of grain by 18.6 and 30.0 per cent at 40 lb. and 80 lb. doses respectively over no-manure control. Compost did not show any effect in all these three years under report. Statistical analysis of the data showed that the differences due to application of P and K either alone or in combinations were not significant in all the three years.

Parmanent manurial trial with recommended methods.—One permanent manurial trial was initiated during the year 1959 with a view to compare the efficiency of compost and Ammonium sulphate applied individually and in combination. The treatment consisted of 40 lb. of N applied in the form of either Ammonium sulphate or compost and the combination of the two. The yields obtained with various treatments during the years 1959 and 1960 are given in Table XII below.

TABLE XII
Yield of grain in Kg/Ha
Variety T. 141 (150 days duration)
(Average of 2 years 1959 & 1960)

Treatments	1959		1960	
	Yield in Kg/Ha	Percentage over control	Yield in Kg/Ha	Percentage over control
1. Control (No manure)	2064	100	2710	100
2. 40 lb. N/Ac as compost	2251	109	2823	104
3. 20 lb. N as compost 20 lb. N as Ammonium sulphate/Ac.	2612	127	3147	116
4. 40 lb. N/Ac as Ammonium sulphate . .	2633	128	3005	111
C. D. (0.05) for comparing treatment means	372	..	245	..

The results showed that in both the years all the manurial treatments gave higher yield than no manure control. But the differences between the compost treatment which was applied alone @40 lb. N per acre and that of the control treatment were not statistically significant. Ammonium sulphate applied @40 lb. N per acre recorded the highest grain yield of 2633 Kg/Ha in 1959 and in the year 1960 highest grain yield of 3147 Kg/Ha was recorded in the treatment where both compost and Ammonium sulphate were applied @20 lb. N per acre each but the differences between the above mentioned two treatments were not significant in both the years.

Study of the manurial value of indigenous products.—To study the manurial value of Palm Gur molasses as compared to green manure, compost and sulphate of Ammonia, a field experiment was initiated during the year 1960. The experiment was conducted in a randomised block design with four replications. The manures and fertilizers were applied @30 lb. N/Acre. While green manure, compost and Palm Gur molasses were applied in one dose as

basal dressing, sulphate of Ammonia was applied in two doses, one half at the final puddling and the other half one month after planting. The yields of grain are presented in Table XIII below :

TABLE XIII
Yield of grain in Kg/Ha (lb/acre)
Variety T. 141

Treatments	Kg/Ha	lb/Ac	Percentage over control
Control	3472	3100	100.0
Compost	3311	2956	95.4
Green Manure	3776	3371	108.9
Ammonium Sulphate.	3946	3523	113.7
Palm Gur Molasses	3257	2908	93.8
C. D. (0.05)	104.51	..	..

The results showed that highest yield of 3946 Kg/Ha (3523 lb/Ac) was obtained with application of 30 lb. N as sulphate of Ammonia followed by green manure treatment which gave a yield of 3776 Kg/Ha (3371 lb/Ac). Thus Ammonium sulphate and green manure have given an increased yield of 113.7% and 108.8% respectively over no-manure control. Application of Palm Gur Molasses gave the lowest yield of grain. It was also observed that the mortality of tillers and leaf roller attack was higher in the plots where molasses was applied as compared to other treatments.

Nursery manuring Experiment.—During the year 1960 in an experiment to assess the effect of nursery manuring on the yield of transplanted rice 70 lb. of N/acre of nursery was applied in the form of sulphate of Ammonia 20 days after sowing the seeds in the nursery. Field was manured @ 40 lb. N/acre in two splits. These were compared with other treatments where nursery was not manured. The yields of grain are presented in table XIV below :

TABLE XIV
Nursery Manuring Experiment Grain yield data in Kg/Ha (lb/acre)
Variety T. 141

Treatments	In Kg/Ha	In lb/Ac	Percentage over control
1. No field manuring, No nursery manuring	3189	2844	100.0
2. No field manuring, Nursery manured	2958	2639	90.2
3. Field manured, Nursery not manured	3724	3322	116.8
4. Field manured, Nursery manured	3971	3542	124.5
S. E. of treatment means	±166.7	148.8	
C. D. (0.05) to compare treatment mean	=504	450	

(Nursery manured @70 lb. N as Ammonium sulphate 20 days after sowing Field manured @40 lb. N as Ammonium sulphate in two splits.)

The results showed that highest yield of 3971 Kg/Ha (3542 lb/Ac) was obtained from a treatment where both nursery and field were manured but it was not significantly different from that of the treatment where only field was manured which gave a yield, of 3724 Kg/Ha (3322 lb/Ac). Field manuring alone increased the yield over no manuring in the field while only nursery manuring did not show any effect.

Trials with Green manure crops.—After the termination of the scheme for the improvement of green manure crops for rice financed by the Indian Council of Agricultural Research, fifty five species were maintained. Ten species viz. *Aeschynomene americana*, *Crotalaria usaramoensis*, *Crotalaria striata*, *Phaseolus semi-erectus*, *Sesbania macrocarpa*, *Sesbania sericea*, *Cassia leschenaultiana*, *Indigo* sp., *Sesbania speciosa* and *Cassia tora*, which appeared promising were multiplied and seeds were supplied to various research workers for trials in different parts of the country and also abroad.

One of the experiments conducted under Indian Council of Agricultural Research Scheme was continued to assess the relative efficiency of 10 green manure species applied at 5000 lb. of green matter per acre, with Ammonium sulphate and no-manure control as two other additional treatments on the yield of subsequent rice crop. A late duration variety T. 1242 (160 days duration) was grown in the experiment. The statistical analysis of the grain yield data revealed that *Dhaincha*, *Sesbania speciosa*, *Crotalaria striata*, *Aeschynomene americana*, *Gliricidia maculata* and Ammonium sulphate were significantly superior to no-manure control.

IV. Cultural Trials :

Crop sequence experiment.—To determine the possibility of growing different legumes and cash crops in sequence with main season rice crop the experiment was repeated with nine rotational treatments in four replications. Six different crops besides *dalia* or *Boro* crop of rice were grown during the preceding winter season to determine their suitability for inclusion in sequence of cropping with rice and to study their effect on the succeeding rice crop. A short duration variety PTB. 10 was grown during the main season so that the field might be available for sowing *rabi* crops in the month of November. The different crop sequences tried and the average yields of three years are presented in Table XV(a) below :

TABLE XV(a)

Yield of rice and different single season rotational crops in Kg/Ha

(Average of 3 years 1958, 1959 and 1960)

Rotational treatments	Preceding Rabi Crops	Succeeding Rice Crops.
1. Fallow/Rice	..	2290
2. Rice (PTB-10)/Rice	1252	1991
3. Green manuring Rice/Green manuring—Rice	1660	1911
4. Gram (NP. 58)/Rice	134	2061
5. Groundnut (TMV-2)/Rice	897	2093

Rotational treatments	Preceding Rabi Crops	Succeeding Rice Crops
6. Cotton (P 216F)/Rice	*1118	1930
7. Wheat (NP.718)/Green manuring—Rice	171	2042
8. Linseed (RR-440)/Green manuring—Rice	154	1889
9. Berseem/Rice	**12769	1947

*Seed Cotton.

**Barseem fodder.

It might be seen from the above table that yields of rice crop following wheat—green manuring, gram and groundnut were found to be on the same level which showed the benefits of inclusion of leguminous crop in sequence with rice. The cotton rice rotation besides giving 1118 Kg/Ha of seed cotton also yielded 1930 Kg/Ha of rice grain which proved the benefit of inclusion of cash crops like cotton in sequence with rice.

Double cropping of rice gave quite encouraging results as could be seen from the table XV(b) below :

TABLE XV(b)

Double cropping of rice—Yield of grain in Kg/Ha

(Average of 3 years 1958, 1959 and 1960)

Sl. No.	Rotational treatments	Preceding subsidiary Crop	Succeeding Rice Crop	Total
1.	Fallow/Rice (T.141)	..	2290	2290
2.	Rice/Rice (T.141)	1252	1991	3243
3.	Green manuring Rice/Green manuring—Rice (Ptb.10)	1660	1911	3571

Thus with the proper sequence of cropping 3571 Kg/Ha of paddy could be obtained from the same land provided irrigation facilities were available.

Rotational trial with jute, green manure and rice.—During previous years, three crops of paddy were successfully grown on the same land under irrigated conditions by adjusting the dates of planting and proper selection of varieties

For the last five years, jutes is also grown (from April to July) in stead of an early variety of rice in order to determine the possibility of its introduction in the rotation. The details of the treatments and yield of the crops are given in Table XVI below :

TABLE XVI
Rotational trial with Jute green manure and rice yield in Kg/Ha

Treatments	Rotational crops	Year 1958	Year 1959	Year 1960	Total average yield of paddy
A	Green manure	..	..	..	3531
	Rice (CH.45)	failed	698	failed	
	Rice (T.141)	2884	3139	2475	
B	Rice (PTB.10)	1852	1076	1232	5026
	Rice (CH. 45)	failed	878	failed	
	Rice (T.141)	2773	3126	2384	
C	Rice (PTB. 10)	1938	1312	1032	4155
	Green manure	..	..	..	
	Rice (T.141)	2638	2906	2620	
D	Rice (PTB. 10)	1975	1201	1201	4176
	Jute (JRC. 321)	*1157	*1050	*1033	
	Rice (T.141)	2783	2794	2648	

*Yield of Jute fibre.

As seen from the table above treatment B, where three crops of rice were grown gave the highest grain yield of 5026 Kg/Ha. Treatment D apart from giving a total grain yield of 4176 Kg/Ha also gave 1080 Kg/Ha of jute fibre and thus confirmed the findings of the previous years that introduction of jute in the rotational treatment is highly economical.

Two year rotational trial with fertilizer treatment.—To determine the suitable rotation of crops for rice under similar manuring condition, a field experiment was initiated during the year 1958-59 with nine rotational treatments. The fertilizers doses were so fixed that at the end of two years, each rotational treatment (plot) received 60 lb. each of N and P_2O_5 /Acre. The levels of N and P_2O_5 have been indicated under each crop of rotational treatment in the following table. The yields of various rotational crops with that of succeeding rice crop are presented in the Table XVII.

TABLE XVII

Yield of grain in Kg/Ha (lb/acre)

Sl. No.	Rotational treatments with N and P ₂ O ₅ levels for each crop	First year 1958		Second year 1959		Total yield of rice
		Preceding crops	Succeeding rice crop	Preceding crop	Succeeding rice crop	
1.	Cotton — Rice 40-30 20-0 / Mung — Rice 0-30 0-0	432 (386)	2082 (1859)	207 (185)	1784 (1593)	3866 (3452)
2.	Mung — Rice 0-30 0-0 / Cotton — Rice 40-30 20-0	110 (98)	2201 (2046)	461 (412)	1945 (1737)	4237 (3783)
3.	Groundnut — Rice 20-30 10-0 / Berseem — Rice 20-30 10-0	942 (841)	2381 (2126)	7693 (6869)	2005 (1790)	4386 (3916)
4.	Berseem — Rice 20-30 10-0 / Groundnut — Rice 20-30 10-0	8580 (7661)	2433 (2172)	181 (162)	1857 (1658)	4290 (3830)
5.	Grain — Rice 20-0 / Linseed — Rice 20-30 20-0	31 (28)	2386 (2130)	87 (78)	2026 (1809)	4412 (3939)
6.	Linseed — Rice 20-30 20-0 / Gram — Rice 0-30 20-0	102 (91)	2464 (2200)	50 (45)	1889 (1687)	4353 (3887)
7.	Fallow — Rice 0-0 30-30 / Fallow — Rice 0-0 30-30	..	2116 (1889)	..	1864 (1664)	3979 (3553)
8.	Green manure — Rice 0-15 20-0 / Green manure — Rice 0-15 20-0	1324 (1182)	1027 (926)	733 (655)	1515 (1353)	4609 (4116)
9.	Green manure — Rice 0-15 0-0 / Green manure — Rice 0-15 0-0	..	..	..	..	..
	Fallow — Rice 0-0 30-30 / Fallow — Rice 0-0 30-30 (Unmanured).	..	2223 (1985)	..	1717 (1538)	3940 (3518)
	C.D (0.05)	..	339 (303)	..	..	..

The above table shows that highest yield of 4609 Kg/Ha of paddy grain was obtained from the treatment where four crops of rice were raised during two years with preceding green manure treatment. The rotational treatments Gram-Rice/Linseed-Rice, Linseed-Rice/Gram-Rice, Groundnut-Rice/Berseem-Rice, Berseem-Rice/Groundnut-Rice and Mung-Rice/Cotton-Rice gave more than 4200 Kg/Ha of grain yields besides good yields of subsidiary leguminous and cash crops as seen from the table above.

Herbicides for weed control in rice fields.—This experiment has been in progress for the last eight years to evaluate the comparative efficiency of various selective herbicides for control of weeds in the rice fields in comparison with the hand weeding and Japanese rotary weeder. Some new trade products were included in the years 1959 and 1960. Herbicides were sprayed six weeks after planting @ 2 lb. acid equivalent per acre in 100 gallons of water. Within a few days of spraying the susceptible weeds developed chlorosis and ultimately succumbed to herbicidal action. In general broad leaved weeds were found to be susceptible to herbicides and the members of the Gramineae family resistant to them. The susceptible weeds were affected most when they were young and actively growing and the degree of susceptibility decreased with the advance in maturity. The grain yield of the crop obtained from various treatments are presented in the table XVIII below :—

TABLE XVIII
Efficiency of Selective Herbicides—Yield of Grain in Kg/Ha
Variety T. 141

Sl. No.	Treatments	Yield in Kg/Ha	Percentage over control	Remarks
1.	Control (No herbicide)	3,935	100	Average of 3 years.
2.	Hand weeding	3,415	113	do.
3.	Japanese Weeder	3,353	110	do.
4.	Phenoxyline-30	3,467	114	do.
5.	Agroxone-3	3,460	114	do.
6.	2, 4, 5-T	2,968	..	Average of 2 years
7.	Chloroxone	3,496	115	Average of 3 years
8.	Shell-2, 4-D	3,237	107	do.
9.	Kathon M-7.	3,154	104	do.
10.	Cornox	3,149	104	do.
11.	Isocornox	3,260	107	do.
12.	Fernoxone	3,754	..	Average of 2 years.
13.	Isihara 2, 4-D	2,345	..	Average of 1 year.
14.	Estar-A	3,965	..	do.
15.	Erta-D	3,691	..	do.
16.	Agromore T. C. A.	3,628	..	do.
17.	Agromore Weedazole	3,541	..	do.
18.	Agromore Weedone Chloro I.P.C. . .	3,443	..	do.

As seen from the table above the herbicides Isihara 2, 4-D, Estar 'A', Estar 'D', Agromore T.C.A., Agromore Weedazol and Agromore Weedone Chloro I P.C. were tried only for one year during the three years under report and rest of the herbicides were tried for two or three years. The treatment differences were, however, not significant in each of the three years under report. This might be due to the negligible weed population in the experimental plot as observed in various stages of growth of the crop. Among the herbicides which were tried for three years chloroxone recorded the highest grain yield of 3496 Kg/Ha which was immediately followed by Phenoxylene-30 and Agroxone-3 with 3467 and 3460 Kg/Ha of grain yield respectively. They gave 15 and 14 per cent higher yields respectively than that of control (no herbicide). Among the newly included herbicides Estar 'A' and Fernoxone appear to be promising ones.

Time of spraying herbicides for weed control.—This experiment was in progress upto the year 1958 to determine the suitable time of spraying herbicide for control of weeds in the paddy field. As during previous years, phenoxylene-30 and chloroxone were sprayed 2, 6 and 10 weeks after planting @ 2 lb acid equivalent per acre in 100 gallons of water. Yield data are given in Table XIX below :

TABLE XIX
Yield of grain in Kg/Ha (lb/acre)
Variety BAM.9 (160 days duration)

Sl. No.	Treatments	Weeks after planting			Mean
		2 wks	4 wks	6 wks	
1.	Phenoxylene-30	2094 (1870)	2065 (1845)	2030 (1813)	2063 (1842)
2.	Chloroxone	2206 (1970)	2217 (1979)	1930 (1723)	2118 (1891)
3.	Hand weeding	..	..	..	1964 (1754)
4.	Control	..	..	..	1973 (1762)
	MEAN .	2150 (1920)	2141 (1912)	1900 (1763)	..

There was no significant difference between the yields obtained from different herbicides sprayed at different stages of plant growth. The field was practically free from weeds and so control plots also gave statistically as good results as hand weeding and different herbicides. Chloroxone and Phenoxylene. 30 were found equally effective as far as the yield of crop was concerned. It confirmed previous years' results.

Cultural cum chemical method of weed control.—To determine a judicious combination of cultural *cum* chemical method for efficient control of weeds a field experiment was initiated during 1959. Phenoxylen-30, a selective herbicide which proved its superiority over others in previous years' trials, was sprayed @ 2 lb. acid equivalent per acre. Variety T. 141 (145 days duration) was grown in the experiment. The average yields of grain for two years (1959 and 1960) are presented in Table XX below :

TABLE XX
Yield of grain in Kg/Ha
Variety T. 141

(Average of two years 1959 and 1960)

Sr. No.	Treatments	Yield in Kg/Ha	Percentage over control
1.	Sprayed 2 weeks after planting	2653	101.6
2.	Sprayed 6 weeks after planting	2611	100.0
3.	Sprayed 10 weeks after planting	2545	97.5
4.	Japanese weeder 2 weeks after planting	2632	100.8
5.	Japanese weeder 6 weeks after planting	2760	105.7
6.	Japanese weeder 10 weeks after planting	2610	100.0
7.	Japanese weeder 2 weeks after + spraying 6 weeks after planting	2582	98.9
8.	Japanese weeder 2 weeks after + spraying 10 weeks after planting.	2521	96.6
9.	Japanese weeder 6 weeks after + spraying 10 weeks after planting.	2491	95.4
10.	Spraying 2 weeks after + Japanese weeder 6 weeks after planting	2652	101.6
11.	Spraying 2 weeks after + Japanese weeder 10 weeks after planting.	2550	97.7
12.	Spraying 6 weeks after + Japanese weeder 10 weeks after planting.	2432	93.2
13.	Japanese weeder 2 & 6 weeks + spraying 10 weeks after planting	2612	100.1
14.	Japanese weeder 2, 6 & 10 weeks + spraying 10 weeks after planting.	2535	97.1
15.	Japanese weeder 2, 6 & 10 weeks after planting (only) .	2635	101.0
16.	Hand weeding 6 weeks after + spraying 10 weeks after planting	2620	100.4
17.	Hand weeding 6 weeks after planting (only)	2347	89.9
18.	Control (No treatment)	2610	100.0

The results of both the years when analysed individually did not show statistically significant difference among the various treatment. Highest grain yield of 2760 Kg/Ha was obtained in the treatment in which interculturaling was done by the Japanese rotary hoe six weeks after planting.

Highest grain yield of 2653 Kg/Ha was recorded by the treatment in which the crop was sprayed two weeks after planting closely followed by the treatment in which spraying was done two weeks after planting and subsequently intercultured by Japanese rotary hoe after six weeks of planting.

Double cropping Experiment.—To find out the possibility of growing two crops of rice within the Kharif season taking advantage of the monsoon rain six early duration varieties *viz.*, CH. 45, N. 136, PTB. 10, DCA. 14, CH. 10 and HR. 19 were planted in the second week of July and harvested by the third week of September except the variety HR.19 which was harvested in the first week of October. Two replications of the second crop of rice consisting of the varieties T. 90, GEB. 24, T. 1242, T. 141, MTU.15 and TKM.6 were planted in the 4th week of September and rest of the two replications were planted in the first week of October after the harvest of the latest maturing variety HR.19 belonging to the first crop. The varieties included in the second crop were harvested in two lots *i.e.* 4th week of January and second week of February depending on the dates of transplanting. The yields of grain obtained from both the crops (first and second crop of rice) are presented in table XXI below :

TABLE XXI

Yield of grain in Kg./Ha (lb/Ac)

Variety	First Crop		Second Crop		
	Kg/Ha	lb/ac	Variety	Kg/Ha	lb/ac
CH-10 . .	1522	1359	T.141	436	389
CH-45 . .	2190	1956	T.1242	436	389
N-136 . . .	2020	1803	MTU.15	821	733
PTB.10 . .	2319	2070	TKM.6	111	99
DCA-14. .	1920	1714	T.90 . .	771	688
HR-19 . . .	2293	2048	GEB.24	389	347

It might be seen from the table above that the variety PTB.10 was the highest yielder among the first crop of six early duration varieties which yielded 2319 Kg/Ha followed by HR-19 with a grain yield of 2293 Kg/Ha. Among the varieties grown as second crop MTU-15 and T.90 recorded the grain yield of 821 and 771 Kg/Ha respectively. Rest of the varieties gave significantly lower yield than the above mentioned two varieties. The yield of the varieties belonging to the second crop was poor partly due to very late planting which resulted in small vegetative phase of the crop before flowering and partly due to the severe attack of two broods of stem borers.

Spacing × No. of seedlings per hill.—To find out the optimum spacing and optimum number of seedlings per hill a field experiment was initiated during the year 1959. The experiment was conducted in a split plot design with spacings (15 Cm. × 7.5 Cm., 15 Cm. × 15 Cm., 15 Cm. × 22.5 Cm. and 15 Cm. × 30 Cm.) as main plot treatment and no. of seedlings (2, 5 and 8 per hill) as sub-plot treatment. The average grain yield data are presented in the Table XXII below :

TABLE XXII
Yield of grain in Kg/Ha
Variety T. 141

(Average of 2 years 1959 and 1960)

Spacing	2/Hill	5/Hill	8/Hill	Mean
15 Cm. × 7.5 Cm.	2695	2784	2438	2639
15 Cm. × 15 Cm.	2553	2686	2675	2615
15 Cm. × 22.5 Cm.	2355	2642	2655	2551
15 Cm. × 30 Cm.	1980	2589	2809	2459
MEAN	2396	2675	2627	

Among the different spacings tried 15 Cm. × 15 Cm. was found to be quite optimum which recorded the grain yield of 2615 Kg/Ha. So far the number of seedlings per hill was concerned five seedlings per hill was found to be distinctly superior to two seedlings per hill there being no difference between five and eight seedlings per hill. It was also observed that with wider spacing higher number of seedlings per hill was required.

V. Cultural-cum-manurial trials :

Experimental technique.—To study the field technique of application of nitrogenous fertilizer at the levels of 0, 20, 40, 60, and 80 lb N per acre, temporary and permanent bunds were made against leaching and lateral movement of sulphate of ammonia. Temporary bunds were raised little before the application of fertilizer while permanent bunds were prepared in the preceding summer months and consolidated. At the time of puddling the fields, they were further strengthened and consolidated. The experiment was conducted

during the year 1958 in a split plot design with types of bunds in the main plot and levels of nitrogen in the sub-plots. A late duration variety T. 1242 (160 days duration) was grown in the experiment. The yield of grain is given below in Table XXIII.

TABLE XXIII
Mean yield of grain in Kg/Ha (lb per acre)

Types of bunds	Levels of N					Mean
	No.	N 20	N40	N60	N80	
Permanent . . .	3189 (2847)	3376 (3014)	3096 (2764)	2556 (2282)	2219 (1981)	2886 (2577)
Temporary . . .	3063 (2735)	3081 (2751)	2905 (2594)	2277 (2033)	2283 (2038)	2722 (2430)
MEAN . . .	3126 (2791)	3229 (2883)	3000 (2679)	2417 (2158)	2251 (2010)	
C. D. (0.05) for comparing bund means					209	(187)
C. D. (0.05) for comparing nitrogen means					420	(375)
C. D. (0.05) for comparing nitrogen means within a particular type of bund.					595	(531)
C. D. (0.05) for comparing bund means within a level of N					567	(506)

The above table revealed that there was no difference in yield due to permanent and temporary bunds. The differences in yield due to various levels of nitrogen were highly significant. The levels of N-60 and N-80 were significantly inferior to N0, N20, and N40, the latter three being at par with each other. There was no interaction between types of bunds and levels of fertilizers.

Cultural practices-cum-fertilizer experiment.—To determine the optimum requirement of cultural and manurial requirements for rice crop five factors *viz.*, Forms of fertilizer, Age of seedling, time of planting, spacing and number of seedlings per hill were tried at two levels each in a 2^5 confounded factorial experiment with two replications. The following treatment combinations were included in the trial.

Treatments	Levels
(A) Forms of fertilizer	(i) Ammonium sulphate at 30 lb N per acre. (ii) Calcium—Ammonium nitrate at 30 lb. N per acre.
(B) Age of seedling	(i) 40 days old (ii) 55 days old
(C) Time of planting	(i) 30th July (ii) 30th August
(D) Spacing	(i) 9" × 6" (ii) 12" × 6"
(E) No. of seedlings per hill	(i) 2 seedlings (ii) 4 seedlings

A late duration variety T. 1242 was grown in the experiment. The yield data are presented below in Table XXIV.

TABLE XXIV
Yield of grain in Kg/Ha (lb per acre)

Treatments	1st	2nd
A. Forms of fertilizers	3119 (2785)	2927 (2613)
B. Age of seedling	3004 (2682)	3042 (2716)
C. Time of planting	3175 (2835)	2871 (2563)
D. Spacing	3054 (2727)	2992 (2671)
E. No. of seedlings per hill	3056 (2729)	2989 (2669)
C. D. (0.05) to compare levels	119	(106)

The data reveal that out of five factors tested in the experiment only two factors *i.e.*, forms of fertilizers and dates of planting were found to be statistically significant. sulphate of Ammonia gave 172 lb. extra grain yield over that of Calcium Ammonium nitrate. Fifty five days old seedling depressed the yield by 272 lb. per acre as compared to 40 days old seedling. There was no interaction among these factors.

Methods of rice culture.—To compare the efficiency of five different methods of cultivation, Japanese, Chinese, Thackersy, Wave and recommended methods were tested in a randomised block design with four replications. A medium duration variety, T. 141 was used in the experiment. The yield data are given in Table XXV below :

TABLE XXV
Yield of grain in Kg/Ha (lb per acre)

Methods	Kg/ Hectare	lb/ acre	Percentage over re- commen- ded method
Recommended	2380	2125	100
Japanese	3064	2736	129.
Chinese	2439	2178	102
Thackersy	2025	1808	95
Wave	2504	2236	118
C. D. (0.05)	349	312	

The table shows that Japanese method gave significantly higher yield over all other methods of cultivation. Thackersy method gave the least yield. There was no significant difference in yield obtained with wave, Chinese and recommended methods which were significantly superior to Thackersy method.

Chinese method of Rice cultivation.—In the sub-committee meeting of the Rice Committee held at Central Rice Research Institute, Cuttack on 24th February 1959, it was decided that the Chinese method of rice cultivation which is claimed to have given very high yields in China should be compared with Japanese method and local improved methods at selected locations. Accordingly a programme for co-ordinated trial was drawn up and the trial was scheduled to be conducted at 31 centres. Central Rice Research Institute was chosen to be one of the centres for conducting the experiment. At each centre a randomised block experiment with six replications was conducted. The three treatments are (A) Chinese (B) Japanese and (C) Local improved method (Recommended). A late duration variety of paddy, BAM.9 (165 days duration) was grown in the experiment.

The yields of grain and straw in Kg/Ha (lb/A) and the costs of cultivation are given in table XXVI (a). The data pertain to the Central Rice Research Institute only.

TABLE XXVI (a)

Methods	Yield of grain		Yield of straw		Cost in Rs.
	in Kg/Ha	(lb/a)	in Kg/Ha	(lb/a)	
Chinese	2980	(2661)	7416	(6621)	5,849.12
Japanese	2561	(2287)	6401	(5715)	474.77
Recommended	3276	(2925)	6180	(5518)	411.88

S. Em of treatments = ± 182.86

$\pm 164.48^*$

The yield differences among the three methods, Chinese, Japanese and Recommended were not found to be statistically significant.

Significantly higher straw yield was obtained in Chinese method as compared to that of Japanese and recommended method.

The main emphasis in Chinese method was on (1) deep ploughing *i.e.*, digging 3' deep (2) close spacing and (3) heavy application of organic manures and mixing that with different layers of soil. The expenditure on these items involved a heavy cost of about Rs. 5,306.00 per acre which will not be remunerative. Other than these items cost on all the three methods are comparable.

Residual study.—During the year 1960 the residual effect of different methods of rice cultivation was assessed without any fresh application of manures and fertilizers. The yields of grain obtained from different methods are presented in table XXVI (b) below :

TABLE XXVI (b)

Methods	Yield of grain	
	in Kg/Ha	in lb/Acre
Chinese	3835	3424
Japanese	3553	3172
Recommended	3484	3110

The data showed that the treatment differences were not statistically significant. This was due to the fact that in all the methods organic manure in the form of compost was applied in the year 1959, the residual effect of which was manifested during the year 1960.

Experiment with bacterial manure (Azotobacterin).—To assess the manurial value of bacterial culture, Azotobacterin received from Moscow two field experiments both under upland and low land conditions were conducted during the years 1959 and 1960. The Azotobacterin was inoculated alone and in combinations with NP, and PK. The yields of grain are presented in Table XXVII below :

TABLE XXVII

Yield in Kg/Ha

Upland (Var. PTB. 10)

(Average of two years 1959 and 1960)

Manure/Azotobacter treatment	No manure	30 lb N 50 lb P ₂ O ₅ per acre	+50 lb P ₂ O ₅ + 30 lb K ₂ O per acre	Mean
Without Azotobacterin	1599	2051	1657	1769
With Azotobacterin	1522	2415	1728	1888
MEAN	1560	2233	1693	

C. D. (0.05) to compare manure means = 265 Kg/Ha

C. D. (0.05) to compare Azotobacterin treatment means = 117 Kg/Ha

C. D. (0.05) to compare Azotobacterin treatment within manures = 203 Kg/Ha

C. D. (0.05) to compare manures within Azotobacterin treatment = 361 Kg/Ha

It might be seen from the "above table that under upland condition control treatment gave an yield of 1599 Kg/Ha while Azotobacterin treatment alone did not give any increase in yield. The manurial levels of 30 lb. P_2O_5 and 30 lb. K_2O per acre alone and in combination with Azotobacterin gave the yields of 1657 and 1728 Kg/Ha respectively. The manurial treatment of 30 lb. N+30 lb. P_2O_5 increased the yield from 1599 Kg/Ha to 2051 Kg/Ha while under similar manurial level with Azotobacterin the yield increased significantly up to 2415 Kg/Ha which was 17.7 per cent higher than that of the treatment where only 30 lb. N and 30 lb. P_2O_5 was applied without Azotobacterin. Under low land condition Azotobacter alone or in association with 30 lb. N and 30 lb. P_2O_5 did not increase the yield as was found under upland conditions.

Early varieties × spacing × Nitrogen.—To study the differential response of early duration varieties to different spacings and levels of nitrogen, two varieties *viz.*, PTB-10 (high tillering) and N-136 (low tillering) were tried with four spacings, 15 cm. × 7.5 cm., 15 cm. × 15 cm., 15 cm. × 22.5 cm. and 15 cm. × 30 cm. under four levels of N *i.e.*, 0, 30, 60 and 90 lb N/Ac in a split plot design with levels of nitrogen in the main plot and varieties × spacing in the sub-plot.

The yields of grain obtained during the year 1959 are presented below in Table XXVIII(a) and (b) :

TABLE XXVIII (a)
Yield of grain in Kg/Ha (lb/ac)

(Year 1959)

Levels of N	PTB. 10	N. 136	Mean	
N ₀	2372 (2118)	1412 (1261)	1892 (1689)	S. E. of N means = ±195.15 (± 174.24)
N ₃₀	2634 (2352)	1676 (1496)	2155 (1924)	C. D. (0.05) per hectare to compare N means 878.43 (784.31)
N ₆₀	2544 (2271)	1693 (1512)	2119 (1892)	
N ₉₀	1506 (1,02)	1335 (1192)	1621 (1447)	
MEAN	2364 (2111)	1529 (1365)	1947 (1738)	

S. E. of variety means = ±49.35 (±44.06)

C. D. (0.05) per hectare to compare variety means = 143.16 (127.82)**

S. E. of variety means within a N level ±98.33 (±88.24)

C. D. (0.05) per hectare to compare variety means within a level of N = 286.33
(255.65)**

S. E. of N means within a variety = ± 207.23 (±185.03)

C. D. (0.05) per hectare to compare N means within a variety = 893.71 (797.96)**

TABLE XXVIII (b)

Yield of grain in Kg/Ha (lb/ac)

(Year 1959)

Spacings	PTB. 10	N. 136	Mean	
15 Cm. $\times$ 7½ Cm. (6" $\times$ 3")	2166 (1934)	1241 (1108)	1704 (1521)	S. E. of spacing means = $\pm$ 69.91 ($\pm$ 62.42)
15 Cm. $\times$ 15 Cm. (6" $\times$ 6")	2452 (2189)	1515 (1353)	1984 (1771)	C. D. (0.05) per hectare to compare spacing means = 202.93 (181.19)**
15 Cm. $\times$ 22½ Cm. (6" $\times$ 9")	2446 (2184)	1605 (1433)	2025 (1808)	
15 Cm. $\times$ 30 Cm. (6" $\times$ 12")	2302 (2136)	1754 (1566)	2073 (1851)	
MEAN	2361 (2111)	1529 (1365)	1917 (1738)	

The interaction between varieties and nitrogen was significant while the interaction between variety $\times$ spacing was not significant. Among the different levels of N tried 30 lb N/Acre gave the highest yield followed by 60 lb N/A. The maximum dose of 90 lb N/A gave lower yield than that of control. This might be due to the fact that crop in 90 lb N level severely lodged at the preflowering stage.

Among the four spacings tried in the experiment 15 Cm. $\times$ 7½ Cm., 15 Cm. $\times$ 15 Cm., 15 Cm. $\times$ 22½ Cm. and 15 Cm. $\times$ 30 Cm., it was observed that the spacing of 15 Cm. $\times$ 7½ Cm. had given the lowest yield which was significantly lower than that of other spacings. Rest of the spacings gave similar yield performance, there being no significant difference among them. The spacing of 15 $\times$ 15 cms. (6" $\times$ 6") and 22.5 $\times$ 15 cm. (9" $\times$ 6") are optimum for this group.

The experiment was repeated during the year 1960 and the result confirmed the findings of the year 1959 except that the interaction between varieties $\times$ nitrogen was not significant.

Medium varieties $\times$ spacing $\times$ nitrogen.—To study the differential response of medium duration varieties to different spacings and levels of N, two varieties viz., T.141 (145 days) and T.1242 (160 days) were tried with four spacings 15 cm. $\times$ 7.5 cm., 15 cm. $\times$ 15 cm., 15 cm. $\times$ 22.5 cm., 15 cm. $\times$ 30 cm. under four levels of nitrogen i.e., 0, 30, 60 and 90 lb N/A in a split plot design with levels of nitrogen in the main plot and varieties $\times$ spacing in the sub-plot. The experiment was initiated during the year 1959.

The yield of grain obtained is presented in Table XXIX(a) and (b) below :

TABLE XXIX (a)
Yield of grain in Kg/Ha (lb/A)

(Year 1959)

Level of N	T. 141	T. 1242	Mean	
N ₀	1562 (1395)	1182 (1056)	1373 (1226)	S.E. of N means = ± 102.59 (91.60)
N ₃₀	3207 (2863)	1942 (1734)	2575 (2299)	C.D. (0.05) per hectare to com- pare N means 290.84** (259.68)
N ₆₀	2952 (2636)	1730 (1545)	2342 (2091)	
N ₉₀	2355 (2103)	1346 (1202)	1851 (1653)	
MEAN	2519 (2249)	1550 (1384)		

S. E. of variety means = ± 56.29 (± 50.26)

C. D. (0.05) per hectare to compare variety means = 159.50 (142.41)

S. E. of nitrogen means within a variety = ± 129.88 (± 115.96)

C. D. (0.05) per hectare to compare N means within a variety = 419.07 (374.17)**

S. E. of variety means within a level of N = ± 112.40 (± 100.36)

C. D. (0.05) per hectare to compare variety means within a level of N = 318.99 (284.81)*

TABLE XXIX (b)
Yield of grain in Kg/Ha (lb/A)

(Year 1959)

Spacings	T. 141	T. 1242	Mean
*15 Cm. × 7½ Cm. (6" × 3")	2474 (2209)	1587 (1417)	2031 (1813)
15 Cm. × 15 Cm. (6" × 6")	2444 (2182)	1584 (1414)	2014 (1798)
15 Cm. × 22½ Cm. (6" × 9")	2641 (2358)	1558 (1391)	2100 (1875)
15 Cm. × 30 Cm. (6" × 12")	2517 (2247)	1472 (1314)	1995 (1781)
MEAN	2519 (2249)	1550 (1384)	

It might be seen that the differences in yield due to various levels of N were significant. Highest yield of 2575 Kg/Ha was obtained with 30 lb N/A. A dose of 90 lb N/A, the highest dose tried in the experiment gave significantly lower yield than both 30 and 60 lb N levels there being no significant difference between the latter two levels. The variety $\times$ nitrogen interaction was significant. At all the levels of nitrogen *i.e.*, from 0 to 90 lb N/acre T. 141 gave significantly higher yield than that of T.1242. The differences in yield due to spacings were not significant.

The interactions between variety $\times$ spacing and between spacing $\times$ N were not significant in the case of the medium types.

This experiment was repeated during the year 1960. The results of 1960 showed that the interaction between varieties $\times$ nitrogen, varieties $\times$ spacing and spacing $\times$ nitrogen were not significant. Among the two varieties T.141 was significantly superior to T.1242, so far the grain yield was concerned.

Among the different levels of N tried no-manure control gave the least yield. With every additional dose of N, the yield of grain increased but, however, there was no difference among the different levels of N tried. During last year 30 lb N dose gave significantly higher yield than N 0 and 90 lb N/Acre.

Among the four spacings tried, 15 cm. $\times$ 7.5 cm., 15 Cm. $\times$ 15Cm., 15 Cm. $\times$ 22.5 Cm. and 15 Cm. $\times$ 30 Cm. a spacing of 15 Cm. $\times$ 22.5 Cm. had given the highest yield. But differences in grain yield due to various spacings were not significant. A spacing of 15 Cm. $\times$ 22.5 Cm. (6" $\times$ 9") is considered optimum for this group.

Water requirement Experiment.—To determine the water requirement of rice crop under different fertilizer treatments pot culture experiments were conducted during the years 1959 and 1960 with 8 manurial treatments including one control and to early duration varieties PTB. 10 and CH. 45. The experiment had two replications.

Water requirements as obtained in various treatments, which is taken as a ratio of the weight of water transpired by the plant during its growth to the weight of dry matter produced (exclusive of roots), are given below in Table XXX.

TABLE XXX

Water requirement of two varieties of rice as effected by different manurial treatments

(Ratio of weight of water transpired in gm. to the weight of dry matter produced in gms)

Manurial treatment	Year 1959			Year 1960	
	Varieties		Mean	Varieties	
	PTB. 10	CH. 45		PTB. 10	CH. 45
1. No manure	566.426	564.087	565.257	737.200	590.970
2. Ammonium sulphate at 30 lb *N/Acre	686.781	576.141	631.461	624.790	577.400
3. F. Y. M. at 30 lb N/Acre	587.448	586.628	587.038	673.700	682.950
4. Superphosphate at 30 lb P ₂ O ₅ /Acre	660.063	551.421	605.742	601.500	613.780
5. Ammonium sulphate @ 15 lb N/Acre + F.Y.M. @ 15 lb N/Acre	566.880	557.263	562.072	626.350	577.890
6. Ammonium sulphate @ 30 lb N + Superphosphate at 30 lb P ₂ O ₅ /Acre.	616.681	683.350	650.016	587.330	633.390
7. F. Y. M. @ 30 lb N/Acre + Superphosphate at 30 lb P ₂ O ₅ /Acre	578.597	515.930	547.264	616.190	569.250
8. Ammonium sulphate @ 15 lb N/Acre + F. Y. M. @ 15 lb N/Acre + Superphosphate @ 30 lb P ₂ O ₅ /Acre.	692.733	633.771	663.252	652.100	579.270
MEAN	619.451	583.574	601.513	639.900	615.610
C. D. (0.05) for treatment means =	134.80			72.28	

The results of the year 1959 indicated that there was no significant difference in water requirement either due to varieties or due to different manurial treatments. During the year 1960, the differences due to varieties as well as the varieties $\times$ treatment interactions were not statistically significant. The ratio of weight of water transpired in gms to the weight of dry matter produced in gms was the highest in control treatment followed immediately by the treatment where only farm yard manure was applied @30 lb N/Acre. Rest of the manurial treatments significantly decreased the water requirement of the rice crop.

VI. Coordinated Varietal trials :

As a measure of coordination between the various Central Institutes, it has been decided to conduct trials simultaneously at different institutes to test the results under different climatic and soil conditions. During the year 1959, trials with N. P. wheat and linseed varieties were conducted at this Institute in cooperation with the Indian Agricultural Research Institute, New Delhi.

Out of ten N. P. wheat varieties N. P. 824 gave the highest yield of 693 Kg/Ha (619 lb/Ac) and was followed by N. P. 761, N. P. 823 and N. P. 797. The difference in yield were not found to be statistically significant. Variety N. P. 828 was severely attacked by *Alternaria* and gave poor yield.

During the year 1960 out of 10 N. P. wheat varieties NP. 825 gave the highest yield of 478 Kg/Ha (427 lb/A) followed by NP. 797 with 455 Kg/Ha (406 lb/A) and NP. 710 with 418 Kg/Ha (373 lb/A). The variety NP. 718 which was used as standard yielded 361 Kg/Ha (322 lb/A). The differences in grain yield were, however, not significant.

The yield performance of 8 rust resistant linseed varieties was also tested in a replicated trial during the year 1959. The general condition of all the varieties was poor and the yields ranged from only 113 to 224 Kg/Ha (100 to 200 lb/Ac).

Botany

I. Maintenance and study of genetic stocks :

One thousand four hundred and thirteen varieties were added to the collection of genetic stocks during this period and the collection stands at 3367. These new varieties had been obtained from sixteen foreign countries e.g., Australia, British Honduras, Burma, China, Columbia, Hungary, Italy, Malaya, Netherlands, Pakistan, Peru, Philippines, Russia, Thailand, United States of America and Viet Nam and different States in India. In response to requests from foreign countries and various states in India seed samples of 1793 types were supplied. After careful study 133 duplicates were deleted from the collection.

The Director, Central Rice Research Institute, continued to be in overall supervision of the FAO scheme for the maintenance of World Genetic Stocks of rice at five centres, including Central Rice Research Institute.

Observations on the morphological characters and occurrence of pigmentation in the different plant parts were made in the new varieties received during this period.

II. Agro-genetical studies :

1. Breeding for high yield and response to heavy soil fertility.

Hybridization between japonica and indica rices.—(a) *Bulk trials.*—A total number of 196 cultures was tried in different generations in the different years under varying fertility conditions. The details of the number of cultures tried in the different generation and the fertility level are given in Table XXXI.

TABLE XXXI

Number of cultures tried, level of fertility and the number of superior cultures in the different years

Year of trial	Generation	Number of cultures tested	Level of fertility (Quantity applied in lb/acre)	Number of significantly superior cultures (over <i>indica</i> parent)
1958	F ₇	15	40 lb N + 18 lb P ₂ O ₅	3
	F ₈	45	Do.	9
1959	F ₇	19	Do.	11
		6	40 lb N + 36 lb P ₂ O ₅	3 (over Indrasail and GEB. 24)
		6	60 lb N + 54 lb P ₂ O ₅	3 (over Indrasail)
	F ₈	15	40 lb N + 18 lb P ₂ O ₅	..
	F ₉	17	Do.	12
		15	Do.	5
1960	F ₈	7	40 lb N + 36 lb P ₂ O ₅	..
		3	60 lb N + 54 lb P ₂ O ₅	..
	F ₁₀	9	40 lb N + 36 lb P ₂ O ₅	5
		7	Do.	3
		32	Do.	..

The results of the bulk trials are summarised yearwise. Results of trials conducted in 1958:—

In the F₇ generation trial, 3 cultures were significantly superior to their *indica* parent and 5 others yielded more than their *indica* parent. In the second trial at F₈ generation amongst the 45 cultures tested nine were significantly superior to their *indica* parent. The yield of the superior cultures ranged from 2143 to 3347 lb per acre. Twenty six cultures gave increased yield over their *indica* parent.

Results of trials conducted in 1959

In the first trial at F₇ generation 11 cultures yielding 15 to 47 per cent more than their respective *indica* parent were significantly superior. Six cultures gave increased yield over *indica* parent. In the remaining two trials in F₇, 3 cultures were significantly superior to the two controls Indrasail and GEB. 24 and three more cultures were significantly superior to Indrasail only. None of the cultures was superior to all the controls, Indrasail, T. 141, T. 124₂ and GEB. 24.

None of the cultures included in the F_8 generation trial was superior to the controls.

In the F_9 generation trials, 12 cultures in the first trial and 5 in the second, gave significantly increased yield over their respective *indica* parent. The superior cultures in the first trial yielded 14 to 114 per cent more than the respective *indica* parent.

Results of trials conducted in 1960

None of the cultures included for trial in F_8 generation was significantly superior to their *indica* parent. The yield of superior cultures ranged from 2414 to 2832 lb. per acre.

Five cultures in the first trial (F_{10} generation) yielding respectively 3184, 2665, 2538, 2531, and 2866 lb per acre and 3 cultures in the second trial yielding respectively 2207, 2477 and 2647 lb. per acre were significantly superior in yield to their *indica* parent. The performance of the cultures was very poor in the third trial.

(b) Twenty-nine progeny row trials were conducted during this period and a total number of 2060 progenies was tried in the different generations. The number of progenies tried in the different generations, the level of fertility and the number of superior progenies in the respective trials are given in Table. XXXI.

TABLE XXXII

Number of progenies trial, level of fertility and the number of superior progenies in the different years

Year of trial	Generation	Number of progenies tested	Level of fertility quantity applied in lb/acre.	Number of significantly superior families
1958	F_5	44 44	40 lb N 18 lb P_2O_5	
	F_6	244 111	40 lb. N 18 lb P_2O_5	62 12
	F_7	108	40 lb N 18 lb P_2O_5	10
	F_8	167	40 lb N 18 lb P_2O_5	40
1959	F_8	208	{ no manure 20 lb N 18 lb P_2O_5 40 lb N 36 lb P_2O_5 60 lb N 54 lb P_2O_5	
	F_6	48 48	40 lb N 18 lb P_2O_5 40 lb N 36 lb P_2O_5	24 10
	F_7	113 112	{ 40 lb N 36 lb P_2O_5 60 lb N 54 lb P_2O_5	48 13
		56	40 lb N 18 lb P_2O_5	13
	F_8	113	40 lb N 18 lb P_2O_5	72
	F_9	26	40 lb N 18 lb P_2O_5	7
		27	40 lb N 18 lb P_2O_5	6
		35	40 lb N 18 lb P_2O_5	9

TABLE XXXII—*contd.*

Year of trial	Generation	Number of progenies tested	Level of fertility quantity applied in lb/acre	Number of significantly superior families
1960	F ₃	60	60 lb N + 36 lb P ₂ O ₅	82 S. P. S.
	F ₆	33	no manure	123 S. P. S.
		31	20 lb N + 18 lb P ₂ O ₅	
		39	40 lb N + 36 lb P ₂ O ₅	
		29	60 lb N + 54 lb P ₂ O ₅	
	F ₇	48	20 lb N + 18 lb P ₂ O ₅	29
	F ₈	29	20 lb N + 18 lb P ₂ O ₅	20
		57	40 lb N + 36 lb P ₂ O ₅	..
		56	60 lb N + 54 lb P ₂ O ₅	..
	F ₉	53	20 lb N + 18 lb P ₂ O ₅	32
		53	40 lb N + 36 lb P ₂ O ₅	3
	F ₁₀	26	20 lb N + 18 lb P ₂ O ₅	11
		42	40 lb N + 36 lb P ₂ O ₅	1 (Over T. 141 and Bam. 9)

S. P. S.—Single Plant Selection.

The results of the trials are summarised yearwise. Results of trial conducted in 1958 :—

No family was significantly superior to the respective *indica* parent in F₅ generation. Seventy four families in F₆ generation, 10 in F₇ and 40 in F₈ gave increased yield over their respective *indica* parent which was statistically significant. The acre yield of superior families ranged from 1777 lb. to 3468 lb.

Results of trials conducted in 1959

From 208 families grown in the F₅ generation, 904 field selections were made for further trial. In the F₆ generation 24 families in the first trial and 10 in the second trial gave significantly increased yield over their respective *indica* parent.

Two trials were conducted in the F₇ generation. In the trial conducted under two levels of fertility with the same progenies, 48 families were significantly superior to their respective *indica* parent under one level of fertility (40 lb N + 36 lb P₂O₅) and 13 families gave significantly increased yield in the second fertility level (60 lb N + 54 lb P₂O₅). In the second trial, 5 families yielded significantly more than the respective *indica* parent. Increased yield over *indica* parent was obtained in 15 more cultures.

Seventy two families were significantly superior to their respective *indica* parent. Of these, 25 in the F₈ generation trial are from GEB. 24 combination, 41 from Co. 25 combination, 3 from Early Kolipi combination, 2 from MO₂ combination and 1 from T.90 combination. All families, from GEB. 24, T. 90 and Early Kolipi combinations, were late in maturity as compared to the respective *indica* parent. Families from Co.25 combination flowered earlier than Co. 25.

In the trials conducted at F_9 generation in addition to *indica* parents, T.141 and T.812 were also included as controls. Twenty two families were significantly superior to their respective *indica* parent. Of these superior families, only 3 in the second trial and 4 in the third trial gave significantly increased yield over T.812 and T.141 respectively.

Results of trials conducted in 1960

Twenty three progenies from Fukoku $\times$ Bam. 9 combination and 37 from Zuiho $\times$ T.141 combination were included for trial in the F_3 generation. Based on several morphological characters and yield, 82 single plant selections were made.

In the four trials at F_6 generation, a total number of 123 selections was made.

In the only trial in F_7 generation, 29 cultures yielding from 1210 to 3064 lb per acre were significantly superior to their *indica* parent.

Only 20 cultures were significantly superior in yield to their *indica* parent in the trials in the F_8 generation. One culture from Norin. 8 $\times$ Dharial combination gave an yield of 3500 lb per acre. The yield of 14 cultures in the third trial ranged from 3071 to 3722 lb per acre.

Thirty two cultures with the acre yield ranging from 1016 to 2014 lb were significantly superior to their *indica* parent. Of these, 22 cultures have been derived from Co.25 combination.

In the second F_9 generation trial, two cultures from GEB.24 $\times$ Rikuu 132 combination yielding respectively 2298 and 1881 lb per acre and one culture from MO₂ $\times$ Rikuu 132 combination with an yield of 2594 lb per acre were superior to T.141, which gave an yield of 1430 lb per acre.

Of the 26 cultures in the trial in F_2 generation 11 cultures with acre yield ranging from 2549 to 3743 lb were superior to their respective *indica* parent.

In the last trial, the cultures were tested against two standards viz., T.141 and Bam. 9. Only one culture belonging to Patnai 23 $\times$ Rikuu 132 combination (3777 lb per acre) was significantly superior to both standards. Three cultures in this combination gave more than 3500 lb per acre.

2. Preliminary yield trial of introductions.

As in the previous years, selected types from genetic stocks and superior varieties carried over from the respective previous year's trials were tested in preliminary yield trials. The number of varieties tested in each year, significantly superior types and their acre yields are given below in Table XXXIII.

TABLE XXXIII

Duration of trial	101-110 days				111-120 days				131-140 days				141-150 days		151-170 days		
	Number of types tested	Number of types super-ior to control	Acre yield (in lb per acre)	Number of types tested	Number of types super-ior to control	Acre yield (in lb per acre)	Number of types tested	Number of types super-ior to control	Number of types tested	Acre yield (in lb per acre)	Number of types super-ior to control	Number of types tested	Number of types super-ior to control	Acre yield (in lb per acre)	Number of types tested	Number of types super-ior to control	Acre yield (in lb per acre)
1951	17+3	..	..	..	..	..	17+3	..	..	..	..	23+2	..	..	23+2	1 (Ac.2734)	2797
1959	7+2	..	..	14+2	..	..	8+1	..	14+1	1797	1 (GS.714)	16+2	..	..	16+2	..	..
1960	7+1	..	..	7+1	..	815	7+1	..	..	..	..	5+1 16+3	..	..	5+1 16+3	..	..

3. *Breeding for high yield and early maturity.*

In 1948 a project was initiated to evolve early maturing, high yielding strains using *indica* parents only. Since then this project has been in progress and 6 relatively homozygous strains have been evolved and have been numbered as CR. 1, CR. 2, CR. 3, CR. 4, CR. 5 and CR. 6. CR. 1 to CR. 4 are medium grained and CR. 5 and CR. 6 have fine grains. These strains were tested against Slo. 9 and T.608 under two levels of fertility viz. 20 lb. N+18 lb. P₂O₅ and 40 lb. N+36 lb. P₂O₅.

At the first level, CR. 3 and CR. 4 yielding 2057 and 2153 lb. per acre respectively were as good as Slo. 9. The cultures, in general, came to flower after 95 days from the date of sowing.

At the second level, all medium grained strains were significantly superior to Slo. 9 (1414 lb. per acre). CR. 4 gave the maximum yield of 2572 lb. per acre.

These strains were distributed to several states to assess their performance under different conditions. They are also being maintained here and multiplied.

4. *Breeding for upland conditions.*

This project was being carried out in the Botany section till 1959 after which this was taken over by the physiology section. Four preliminary yield trials (two in each year) were carried out with 77 early varieties under rainfed conditions. In the first year only one variety, Ac. 4, yielding 2705 lb. per acre was significantly superior to the standard B.76 and 7 other varieties gave increased yield over the control. In the second year, Ac. 3252 which yielded 2253 lb. per acre was significantly superior to the standard B.76-116. Two other varieties viz. Ac. 360 and GS. 742 yielded more than the control which gave an yield of 1591 lb. per acre.

In addition, ten varieties already included in the upland trial, were also tried under irrigated conditions. While none of the varieties was significantly superior to the standard in the first year, four varieties viz. Ac. 4, Ac. 360, Ac. 486 and Ac. 3902 yielding respectively 2353, 2279, 2144 and 2132 lb. per acre were significantly superior to the standard.

In general, the varieties yielded more under irrigated conditions and the loss in yield under rainfed condition varied from 7-57 percent.

5. *Breeding for high yield combined with quality.*

Under the project to evolve fine table rice, eight trials were carried out during the period 1958 and 1959. Of these, six were progeny row trials and two were bulk trials. In the three progeny row trials (F₄, F₅ and F₆) carried out in 1958, a total number of 164 cultures from 8 inter-*indica* combinations was tried and 33 cultures yielding from 1629 to 3746 lb. per acre were significantly superior to their respective high yielding parent. Of the 9 cultures tried in bulk trial, 6 cultures yielding 1872 to 2433 lb. per acre were significantly superior to their respective high yielding *indica* parent. Selections from superior cultures were carried forward for further trials.

In the year 1959, 164 cultures from 8 inter-*indica* combinations were tried in three progeny row trials (F_5 , F_6 and F_7). The general performance of the cultures was good. Twenty-nine significantly superior cultures ranging in yield from 2000 to 3485 lb. per acre were selected for making single plan selections.

In the bulk trial (F_7 generation) one culture from N. 136 $\times$ Ptb. 10 combination and one from Ptb. 10 $\times$ Ch. 45 combination yielding respectively 2983 and 2459 lb. per acre were significantly superior to their high yielding parent. One hundred and thirty two cultures were tested in 1960 in three different generations *viz.* F_6 , F_7 and F_8 .

Of the 50 cultures tried in F_6 generation, 20 cultures (17 fine grained) 20 cultures yielding from 2665 to 4164 lb. per acre were significantly superior to their respective high yielding parent while 21 other cultures yielded more than the high yielding parent. The cross combinations, significantly superior cultures and their yield are given in Table XXXIV.

TABLE XXXIV

Cross Combination	Number of culture	Yield in lb/acre
T.2165 $\times$ Sathika	11-11	3223
	11-21	3030
	12-3	2803
	12-4	3423
	13-6	3203
	13-7	3043
	14-9	3344
	15-1	3130
	15-2	3037
	13-8	3383
T.2165 $\times$ N.136	16-10	4164
	16-12	3483
	19-6	3056
	22-7	3276
	24-25	2736
	25-47	2989
	27-27	2749
	28-29	2656
T.90 $\times$ Pulut Nangka	29-32	3070
	39-39	3270

In trial at F_7 generation, the general stand was unsatisfactory and only 25 selections were made for further trials.

Two trials were conducted in F_8 generation. In the first trial, out of the 14 cultures tested, 7 from the combination Ptb. 10 $\times$ Ch. 45 with acre yield ranging from 2037 to 2621 lb. were significantly superior to the high yielding parent Ptb. 10. The superior cultures are coarse grained.

Of the 30 cultures (N. 136 $\times$ Ptb. 10) included in the second trial, 25 were significantly superior to Ptb. 10, the high yielding parent and their acre yield ranged from 2502 to 3884 lb. Among these, 4 cultures yielded more than 3500 lb. per acre.

6. Improving yield of Basmati rices.

Secondary selection was carried out in three Basumati types to obtain high yielding selections. These selections were grown in 1960 and on the basis of their performance in the field and laboratory observation 50 single plant selections have been retained.

7. Breeding for disease resistance.

In this project now in progress in Co-operation with the mycologist, a total number of 217 cultures was tried during 1958 and 1959. As usual, the trials were replicated and the cultures were flanked by Co.13 the susceptible parent. Further, the experiment was carried out under high fertility condition, i.e. 69 lb. N and 36 lb. P_2O_5 . The nursery beds were also heavily manured. Observations on the incidence of the disease were taken at three stages i.e. seedling stage, rapid tillering phase and neck infection stage at maturity. Only high yielding early plants possessing resistance to this disease were selected. The number of selections tested each year, number of significantly superior cultures, their range in yield and their duration at advanced stages of testing are given in Table XXXV.

TABLE XXXV

Year	Generation	Number of cultures		Range in flowering duration of cultures	Number of final selections
		Tested	Significantly superior		
1958	F ₄	29	12	..	13
	F ₅	22	6	..	8
	F ₆	40	3	..	18
	F ₇	36	32	..	14
	F ₈	13	13	..	6
	F ₉	6	6	..	7
1959	F ₅	13	8	90-103	13
	F ₆	8	5	89-99	7
	F ₇	18	14	95-118	9
	F ₈	14	12	98-112	9
	F ₉	6	5	105-112	10
	F ₁₀	7	7	105-110	8
	F ₁₁	5	5	108-110	4

In the year 1960, the infection was not severe even in the susceptible variety Co.13. The details of the different progeny row trials carried out are given in Table XXXVI.

TABLE XXXVI

Year	Generation	Number of cultures tested	Number of cultures significantly superior to			Number of single plant selections retained	Range in single plant weight (in gms.)	Range in flowering duration (in days)
			Co. 13	T. 635	T. 141			
1960	F ₆	11	7	4	..	29	21.0-54.0	85-100
	F ₇	11	4	1	..	15	26.0-51.0	86-102
	F ₈	11	7	1	..	23	30.0-61.0	90-110
	F ₉	9	9	9	1	12	40.0-73.0	100-115
	F ₁₀	8	7	6	..	9	51.0-60.0	105-120

Bulk trial.—Of the 10 cultures tried in F₇ generation, none of them was superior to Co.13 in yield (1250 lb. per acre). All the cultures tested in F₈ and F₉ generations (5 and 2) were significantly superior to the standard. The range in acre yield of the superior cultures was from 1382 to 1831 lb. in the F₈ generation and 3581 and 3708 lb. respectively in F₉ generation.

The performance of the cultures in 1959 was unsatisfactory in all the bulk trials.

Nine homozygous cultures from the combination Co.25×Co.13 were tried in 3 generations i.e. F₁₁, F₁₂ and F₁₃ against Co.13 and T.141 in 1960. All three cultures in F₁₁ generation were significantly superior to Co.13 in yield but not to T.141. In the F₁₂ generation, 2 cultures yielding 3107 and 2950 lb. per acre respectively were significantly superior to T.141. The two homozygous cultures in the F₁₃ generation yielded more than T.141 the percentage increase in yield being 14.6 and 13.5 respectively. These cultures are of medium duration and are resistant to blast.

Helminthosporium and blast.—This project was initiated in 1954 with a view to obtain varieties resistant to both blast and helminthosporium. The selections have been made on the basis of resistance to disease, tillering ability, duration and other desirable characters. In 1960, a total number of 15 single plant selections has been finally retained.

8. *Breeding for profuse tillering and high yield.*

In 1954, a dwarf mutant was obtained in a variety T. 1222 which had thin narrow leaves and profuse tillering habit (90-105 tillers per plant). This plant was short-statured with short and sparsely branched panicles. To utilise this profuse tillering habit, this mutant was crossed to Ac.9 a chinese variety and to T.1222 in 1954. This project has been in progress since then.

In 1958, 4 cultures out of the 12 tested in the combination with Ac.9 gave significantly increased yield over AC.9, the increase in yield ranging from 33 to 45%. In the second cross, 3 cultures yielding 3568 to 4280 lb. per acre were significantly superior to T. 1222.

Six cultures carried over from 1958 trial were tried in the next year. Five cultures from dwarf X Ac. 9 combination were significantly superior in yield to the high yielding parent and of these, one was significantly superior to Ac. 9 in the number of ear bearing tillers also. However, none of the plants produced as many tillers as the profuse tillering dwarf. The remaining single culture was not superior to either parent.

Of the 16 cultures tested in the combination with Ac.9 in the year 1960, 14 cultures were significantly superior to Ac.9 and a total number of 44 selections was made in the superior cultures. The maximum number of tillers per plant never exceeded 32.

In another cross with CP. 12, a purple leaved variety from Madhya Pradesh, 18 single plant selections were made based on number of ear-bearing tillers and single plant produce.

9. *Breeding for high yield and low photo-sensitivity.*

It is observed in general that the high yielding varieties are from medium duration group. It is also known that medium and late duration varieties are photo-sensitive in that they are season bound. This behaviour limits the practice of growing the same variety a second time during any year. It was, therefore, proposed to evolve by a crossing programme high yielding types with low-photosensitivity for wider adaptability.

With this object in view the F₃ progenies belonging to 12 cross combinations were grown in the second crop season (1959) to ascertain the photo-periodic behaviour of the cultures. Due to unfavourable climatic conditions the setting was poor. The stubbles of the plants with low photo-sensitivity were grown in main season (1960) to collect enough seeds. The progeny of these (through seeds) was grown in the second crop season and selections made for low photo-sensitivity. The cycle would be followed.

10. *Utilisation of heterosis.*

It has been observed in certain cross combinations that the F₁'s show marked vigour in respect of height, number of earbearing tillers and yield. But, in subsequent generations, the vigour is lost. It is contemplated to utilise this hybrid vigour in the F₁ generation for increased yield. One of the possible methods to utilise this vigour is through vegetative propagation of the F₁ plants. The complications involved and the best method of propagation are under study. This programme of work has been initiated in the year, 1959.

11. *Breeding technique.*

Improvement in rice has been mainly through selection and only a limited number of varieties has been evolved through the pedigree method. This is probably due to the period involved in releasing a variety. The bulk method of breeding is not very efficient and is not adopted in general. Hence it is proposed to adopt a modified bulk breeding method and compare its efficiency with the pedigree and bulk methods. In this method, the material would be treated as bulk till the F_5 generation and from the F_6 generation onwards, the pedigree method would be adopted. The first selection would be in the F_5 generation. The aim in adopting this method is to minimise the number of years required to evolve a variety and yet achieve success.

The work was initiated with two cross combinations *e.g.* Fukoku $\times$ T. 141 and Zuiho $\times$ S. 1092 in the year 1959. Selections were made in both the segregating populations and the different bulk populations were also obtained.

One hundred and fifty-six cultures from the two combinations along with the original bulk and the modified bulk obtained by bulking the remaining F_2 plants after selection were grown in the year 1960 under two levels of fertility *viz.* 20 lb. N + 18 lb. P_2O_5 and 40 lb. N + 36 P_2O_5 .

The performance of the cultures was good under high fertility condition. The general stand of the cultures belonging to Fukoku $\times$ T. 141 combination was good. Three hundred and fifty-six field selections have been made for laboratory studies.

12. *International Co-operative trial.*

The FAO recommended in 1958 that a co-operative trial of high yielding varieties from different countries be conducted in India and in several other countries to test the performances of these types and explore the possibility of their utilization. On their recommendation, 16 varieties received from FAO were tested in a yield trial against suitable standards during these three years.

No variety was significantly superior to the controls in any year. Further, the yield of the varieties in general was not satisfactory. The varieties are, however, being maintained.

13. *Response of dwarf and cultivated types to Gibberellic acid.*

Different concentrations of gibberellic acid *e.g.* 10, 50, 100 and 1000 ppm. were used and treatments included soaking of seeds in the solution, weekly spraying and both. In general, most of the treatments resulted in a significant increase in the height of the treated plants; however, this increase in height was not significant in one dwarf type, Y. 2139. No significant difference was noted for the remaining characters (ear-bearing tillers, sterility, length of panicle and number of grains per panicle) between the treated and untreated plants.

In a separate experiment, treatment with gibberellic acid alone and in combination with indolyl butyric acid at 1000 ppm. resulted in a significant increase only in the height of plants. Differences in the other characters were insignificant.

III. *Fundamental genetics:*

Crosses were made to study the inheritance of hairiness, liguleless condition, anthocyanin pigmentation in the different plant parts, glume size, multiple pistil, photo-periodic sensitivity and brittle culm. Inter-specific crosses were also attempted.

Study of F₁ generation.—In a cross between Ac. 3776, a super-clustered type and Ac. 806 a normal purple type, clustering showed dominance; however, clustering was not prominent as in the parent and only two to three spikelets were found in each cluster.

In the F₁ plants of crosses involving Ac. 1107, a variety with notched kernel and two normal parents, the kernels had no notch.

Presence of hairiness in the spikelets was dominant in the several crosses under study.

With the exception of pigmentation in leaf blade, occurrence of pigmentation in the different plant parts in a large majority of cases showed dominance; but this was not true in all cases.

In crosses involving *glaberrima* types, normal glume showed dominance over medium and long glume. In a few crosses studied, there was variation in the spikelet sterility of the F₁ plants.

F₂ studies.—Liguleless condition—This inheritance study was made in several crosses. Different ratios like 3 present : 1 absent, 15 present : 1 absent and 54 present : 10 absent were obtained indicating that this character was governed by one, two or three pairs of genes in the respective crosses.

Dwarf.—Several dwarf types are available in the collection and a systematic study is in progress to find out the interrelationship of genes. In a cross between profuse tillering dwarf and CP. 12, a ratio of 3 normal : 1 was obtained showing mono-genetic control of dwarfness. A ratio of 54 normal : 10 dwarf was obtained in two other crosses *viz.* T. 1064 × Ch. 17 and T. 1064 × CP. 12 indicating an interaction of three pairs of genes.

However, there was a wide variation for height of plants in the segregating population of a cross between a Japanese dwarf Mursaki 836 and T. 1. Transgressive segregation occurred on either side. In a cross between T. 432 and T. 90 a ratio of 54 normal : 10 dwarf was obtained.

In addition to the above findings, the following ratios were obtained in the inheritance studies dealing with different characters.

Neck leaf—54 Normal : 10 neck leaf.

Beaked lemma—54 Normal : 10 beaked lemma

Undulate rachis—15 Normal : 1 undulate rachis

Verticillate panicle—63 Normal : 1 Verticillate

Modified vegetative spikelet—54 Normal : 1 present

Notching in kernel—9 present : 7 absent.

In the inheritance studies on the occurrence of pigmentation in different plant parts, most of the ratios obtained were similar to those already reported, however, in certain cases evidence indicated a possible interaction of 5 pairs of genes.

Joint segregation worked out in the different crosses showed independent assortment for many of the genes. In several cases where there was a clear evidence of linkage, cross over values could not be obtained for non-availability of appropriate formula. The cross over values obtained in several crosses are given in Table XXXVII.

Cross-over values (%) obtained for the genes governing pigmentation in different plant parts and other characters

	Leaf Sheath	Leaf Blade	Leaf Tip	Auricle	Ligule	Juncture	J. Back	Internode	Pulvinus	Septum	Glume	Sup- tume	Glume	Lema & Palea	Apiculus	Stigmaless	Dwarf	Leaf Axil	Grain Col.	Beaked Lema	Verticillate pan.	Neck leaf	Undulate rachis
L. Sheath	..	10.1	..	6.5	..	3.9	..	30.3	..	..	..	..	..	..	..	2.4	..	10.1	..	..	..	..	..
L. Blade	Pl.	..	..	5.0	..	Pl.	..	..	..	..	..	Close 15.4	..	..	..	..	..	..	ind.	..	..	..	..
Leaf Tip	..	..	..	5.0	..	..	..	..	..	..	..	..	37.6	..	..	..	..	..	..	..	..	..	..
Auricle	..	5.0	5.0	..	..	..	..	20.4	..	..	..	18.6	24.8	23.7	20.0	..	..	..	..	..	..	..	..
Ligule	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Juncture	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
J. Back	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Internode	..	..	..	20.4	..	..	..	..	9.6	..	..	Close	..	..	..	..	..	..	..	..	..	..	..
Pulvinus	..	..	..	..	..	..	..	..	..	..	..	..	..	Close	..	..	..	..	..	..	..	..	..
Septum	..	..	..	18.6	..	..	..	..	..	..	..	..	2.0 Close	2.0 Close	3.0	..	..	..	..	..	..	..	..
Glume	..	..	..	24.8	..	..	..	37.5	25.5	..	..	5.4	..	..	7.0	..	..	5.4	..	..	..	..	..

TABLE XXXVII—*contd.*

	Leaf Sheath	Leaf Blade	Leaf Tip	Auricle	Ligule	Junctura	J. Back	Internode	Pulvinus	Sepalum	Glume	Lemma & Palea	Apiculus	Sitigmalles	Liguleless	Dwarf	Leaf Axil	Grain in Col.	Beaked Lemma	Verticillate pan.	Neck leaf	Undulate rachis
L. & Palea	..	..	..	23.7	..	..	..	..	..	Close 2.0	..	..	9.0 9.0	..	..	..	..	..	..	..	..	..
Apiculus	..	..	..	20	..	..	..	..	..	3.0	7	..	..	..	..	..	..	..	..	36.0	..	..
Stigma	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Liguleless	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
C.R.R.I. Dwarf	14.2	42.2	48.1	41.2	..	34.6	..	..	..	..	..	..	..	..	..	..	25.9	..	..	..	..	..
Leaf Axil	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	16.6	..	..	..	..
Gr. Col.	ind	..	ind	ind	..	ind	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
df. 803	..	37.5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
df. 1064	..	27.5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Beaked—lemma	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Verticillate Panicle	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Neck—leaf	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Undulate rachis	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	46.9	..	14.6	..

Studies in irradiated material.—Several single plant selections in the neutron irradiated As. 35 segregated for dwarfs in the fourth generation in the ratio 3 normal: 1 dwarf. These dwarf plants had broad, dark green foliage.

Chlorophyll deficient types (virescent) were also found in some of the segregating populations in the ratio 3 normal: 1 virescent and 15 normal: 1 virescent.

Albinos were observed as usual in several cultures.

A certain degree of variation was observed in the length of panicle, degree of awning and size of grains.

Inheritance of coleoptile colour.—This study was undertaken to find out whether the nature of segregation for coleoptile colour was different in the different tillers of the same F_1 plant. The seeds from each panicle was grown separately and the coleoptile colour studied in the seedling stage. In all cases, a ratio of 27 purple: 37 green was obtained showing no difference in the nature of segregation among the different tillers.

Another experiment was carried out to ascertain whether any difference in the manner of segregation occurred when the segregating material was raised under different levels of fertility. Seeds of F_1 plants were grown in four levels of fertility *viz.* 20 lb. N, 40 lb. N, 60 lb. N and 80 lb. N and observation was made in the coleoptile colour. The purple colour was found to be governed by two pairs of complementary genes at all levels of fertility.

IV. *Biometrical genetics:*

Available genetical data from India show that several characters like flowering duration, plant height, number of earbearing tillers and a few others have been dealt within a qualitative manner although these exhibit certain features characteristic of any quantitative character. It is now proposed to study the inheritance of some of these characters from a quantitative angle. The inheritance of plant height was taken up in 1959.

As a preliminary step, an experiment was laid out to ascertain the minimum number of plants that should be studied as an unit to provide a reliable estimate of the population. Two cross combinations *viz.*, Murasaki-Koyabozu 836 $\times$ T. 1 and Fukoku $\times$ S. 1092 were studied in F_1 , F_2 and F_3 generations and three characters (plant height, number of ear-bearing tillers and flowering date) were considered. Analysis of the data showed that the measurements from ten plants in an unit could be considered as a reliable estimate. On the basis of this conclusion, the inheritance of plant height was studied in the cross Murasaki-Koyabozu 836 $\times$ T.1. The material included F_1 , F_2 and F_3 population of this combination. The variance in the F_2 was calculated for the different blocks. Likewise the variance between the families and within the families was also obtained. The values for the different components *viz.* D, H, E_1 and E_2 were obtained. The final analysis provided evidence which indicated that the difference between the parents in their height was governed by two blocks of genes. Further, some of the genes within each of the two groups appear to be linked.

V. *Study of lodging and breeding for non-lodging habit:*

Preliminary yield trials were conducted in all the years. A total number of 113 varieties grouped according to their duration was tested against suitable standards in this period. The varieties tested in the respective years, the superior varieties and their range in yield are given in Table. XXXVIII.

TABLE XXXVIII

Duration/year	Early			Medium			Late		Range in yield of superior varieties (lb. per acre)
	Number of varieties		Range in yield of superior varieties (lb. per acre)	Number of varieties		Range in yield of superior varieties (lb. per acre)	Number of varieties		
	Tested	Significantly superior to standard		Tested	Significantly superior to standard		Tested	Significantly superior to standard	
1958	10+1	..	..	6+1	..	..	19+2	9	1944—2962
1959	16+1	4	1702—2436	7+1	2	2843 and 3017	15+1	..	..
1960	12+1	3	1391—1407	12+1	1	2605	16+1	..	..

Bam. 12, Gs. 449, Gs. 473, Gs. 592 and Ac. 3997 showed no lodging tendency and were significantly superior in yield to their respective control. Of these, Gs. 473 is a medium duration type, while the rest belong to early group.

Ac. 49, Ac. 65 and Gs. 99 from the early duration group, Gs. 24 and Gs. 166 from medium duration group and Ac. 1951 from the late group showed resistance to lodging but these were not significantly superior to the standards in their yield.

Progeny row trials.—One hundred and thirty-six cultures in the F_4 generation, 175 in F_5 and 83 in F_6 were tested in replicated progeny row trial in 1960. These cultures had come from 1712 field selections in F_3 , 25 significantly superior cultures in F_4 and 100 selections in F_5 progeny row trial in the previous year.

Eighteen cultures yielding from 2333 to 4051 lb. per acre in F_5 generation and eight cultures in F_6 generation yielding from 2062 to 3219 lb. per acre were significantly superior to their respective high yielding parent. In addition, 613 field selections in F_4 , 2043 in F_5 and 128 in F_6 were made, based on plant height, number of ear-bearing tillers and lodging behaviour.

Studies were also conducted to ascertain whether there is any correlation between morphological and physiological characters with resistance to lodging.

Early non-lodging varieties had in general a low shoot-root ratio varying from 2.0 to 2.8 while a moderate shoot-root ratio (3.1—3.8) was characteristic of medium and late non-lodging types. The culm density was also high in the later group of varieties.

The non-lodging varieties in addition have a greater extent of lignification in the cells than that found in the lodging varieties. The number of layers of lignified cells is also more in the non-lodging types.

The silica content of the tissues in the non-lodging types has been found to be low.

A combination of a number of favourable attributes like low shoot-root ratio, high culm density and a thick band of sclerenchymatous tissue appears necessary for possessing resistance to lodging.

A series of experiments was conducted to estimate (i) the percentage of lodging at different stages of plant growth (ii) the effect of pruning and ridging on lodging and (iii) loss in yield due to lodging. The results of these experiments are summarised below :—

- (i) The percentage lodging of plants at all stages of growth decreased progressively from closer spacing (4" $\times$ 4") to wider spacing (16" $\times$ 16").
- (ii) The percentage of lodging increased with the increase in fertility level provided the spacing is the same.
- (iii) With the spacing of 4" $\times$ 4" and 8" $\times$ 8" the extent of lodging was more in the early types than in the medium and late types. But these latter types lodged to a greater extent when 12" $\times$ 12" and 16" $\times$ 16" spacings were adopted.

- (iv) There was no significant increase in the yield of early varieties beyond 30 lb. N level.
- (v) The ridged plots gave significantly higher yield than the non-ridged plots.
- (vi) The unpruned plots yielded significantly higher than the pruned plots.
- (vii) The loss in yield is maximum (57.2%) when the plants lodged at the time of flowering and minimum (18.6%) when lodging occurs 20 days before flowering. The loss is also comparatively less (4.9%) when the lodging takes place after flowering (10 days after).

VI. Genetics of fertilizer response :

In preliminary studies carried out at this Institute with one *indica* type (Ptb. 10) and a *japonica* type (Norin. 17), it was observed that the uptake of nitrogen was more in the *indica* type than in Norin 17; however, the production of grains per unit quantity of nitrogen absorbed was higher in Norin 17 than in Ptb. 10. With this back-ground information, Norin 17 was crossed to Ptb. 10 and F_1 plants studied in the water culture. These plants showed remarkable hybrid vigour and high nitrogen uptake; but due to high percentage of seed sterility (80 to 95 per cent) the production-uptake ratio could not be obtained. The hybrids had many characters of the *indica* parent and some of their panicles showed unusually elongated terminal branches with spikelets sparsely arranged. Further work is in progress to study the segregating F_2 generation.

VII. Gene assemblage :

Work was initiated to obtain in as few types as possible several of the marker genes now found distributed in many varieties. The preliminary crosses have been made and the work is being continued. Such synthesized types would be of much use in the several breeding and genetical studies. Further, the range of variability afforded in the segregating populations of such gene assemblage would offer great scope in following convergent breeding.

VIII. Survey of the flora of *Oryza* species for useful genes—Nepal and Assam:

A survey of the Jeypore tract carried out during the period 1955-1960 under the scheme sponsored by the Indian Council of Agricultural Research brought to light some new varieties bearing special significance from evolutionary angle. As considerable variation was found in the small area, it is now proposed to initiate a survey of hilly tracts and plains of Assam and also Nepal to collect both indigenous and exotic types.

Response of dwarf and cultivated types to Gibberellic acid.—Different concentrations of gibberellic acid *e. g.* 10, 50, 100 and 1000 ppm. were used and treatments included soaking of seeds in the solution, weekly spraying and both. In general, most of the treatments resulted in a significant increase in the height of the treated plants, however, this increase in height was not significant in one dwarf type, Y. 2139. No significant difference was noted for the remaining characters (ear-bearing tillers, sterility, length of panicle and number of grains per panicle) between the treated and untreated plants.

In a separate experiment, treatment with gibberellic acid alone and in combination with indolyl—butyric acid at 10,000 ppm. resulted in a significant increase only in the height of plants. Differences in the other characters were insignificant.

A few samples of rice varieties were obtained from Manipur and Tripura and some of them showed morphological peculiarities. Amongst the types obtained from Manipur, one variety *Changsan* has a high hulling percentage (79.2%).

A sample of cultivated rice obtained from N.E.F.A. possesses glabrous straw coloured, short and bold grains.

Among the collection obtained from Sikkim was one variety called Lama paddy. When grown under Cuttack conditions the plants reached a height of 200 cm. and have long heavy, and well exerted panicles. The kernels are white, hard and non-glutinous. The variety is coarse grained with thick culm.

Preliminary studies to ascertain the usefulness of these introductions are in progress.

IX-A. Embryological studies in diploid Ptb. 10 :

(i) *Microsporogenesis*.—Complete account of the development of the another wall layers and the pollen grains was worked out. The development of the wall layers of the anthers follows the usual pattern except that the parietal layer at maturity gets crushed and disorganised so that epidermis directly abuts on the tapetum. The development of the pollen anther cell is by usual meiotic divisions and isobilateral tetrads are formed. The pollen grain is trinucleate at the time of dehiscence.

(ii) *Megasporogenesis*.—The development of the megaspore mother cell follows the Polygonum type of embryo sac development as described by Prof. P. Maheswari. The antipodals which are three in number to start with, divide later to form an antipodal tissue.

(iii) *Fertilization*.—The process of pollination and fertilization in respect to the time taken by each step of the process has been worked out.

(a) Embryological studies in haploid.

A haploid plant isolated from a hybrid population of *Fukoku* × *Babar*, was selected for the above purpose.

(i) *Microsporogenesis*.—The development is similar to that of a normal diploid plant except for a few abnormalities.

- (1) The tapetum is uninucleate.
- (2) Irregular and unequal divisions of P.M.C.
- (3) Pollen grains are sterile.
- (4) At maturity sporangia are filled with degenerated mass.
- (5) Sterile anther was found.

(ii) *Megasporogenesis*.—The formation of female gametes is very rare. So far, only two-nucleate embryo sac has been obtained. Sections cut of the ovary showed degeneration of nucellus and other parts of the embryo sac.

(b) *Embryological studies in neutron irradiated dwarf mutant of AS. 35.*

(i) *Microsporogenesis*.—The anther wall layer development is normal as in Ptb. 10, but for the following few abnormalities noted so far.

- (1) Percentage of the pollen fertility is very low.
- (2) T.S. of anther shows degenerated mass.
- (3) Various degrees of degeneration is noted.
- (4) Anther with two vascular bundles is seen.

(ii) *Megasporogenesis*.—The development is of typical polygonum type, with the following abnormalities.

- (1) Empty, degenerated embryo sac.
- (2) Formation of a double ovary.
- (3) The number of antipodals is as high as 19.

(c) *Embryo sac development and the percentage of its formation in Autotetraploid of Seta.*

Embryo sac development is that of the polygonum type and the percentage of the embryo sac information is almost 100%. The study on the percentage functional embryo sacs is in progress.

(d) *Embryo development.*

The development of the embryo from the first to sixth day after pollination was worked out. The difference in the size and shape of the ovary was noted.

(e) Inter-specific and inter-racial hybrids of *oryza* which are sterile or semisterile have been fixed for embryological studies with a view to find out the cause of sterility.

(f) *Embryo culture.*

Embryos were cultured artificially on the agar media with different nutrient solutions. A single plant belonging to F_2 generation was obtained from the F_1 of a cross *sativa* $\times$ *officinalis* through embryo culture. This is being vegetatively propagated and further study is in progress.

IX-B. *Anatomical studies:*

Some observations on germination.—Under laboratory conditions both husked and unhusked seeds were sown on filter papers in petridishes with a little amount of water. The first sign of germination is indicated by the appearance of the plumule and not the radicle. Once the radicle pushes its way, its growth becomes quicker than that of the plumule. Under continuous submergence of the seeds in water, it is found that the plumule appears first as usual and its growth is also quicker than that of the radicle. Under continuous submergence of the seeds in water and in continuous darkness it has been observed that only plumule appears and the radicle does not develop at all.

Structure of the Embryo.—The most noticeable part of the embryo in a section is the scutellum, the upper free part of which has a fleshy projection known as the ventral scale. Below this upper ventral scale and almost at the middle of the free part there is another outgrowth which can be called as the 'inner ventral scale'. On the surface of the embryo this out growth along with the epiblast and the scutellum forms a continuous covering around the plumule. (This 'inner ventral scale' is peculiar to rice embryos only.)

Seedling anatomy.—The structure between the scutellum and the coleoptile is known as the mesocotyl. This structure does not develop externally when the seeds are sown on the surface of the soil or in petridishes kept exposed to light. The internal structure of the mesocotyl is different from those of the root and the stem. The vascular elements are not fully exarch as in the root or fully endarch as in the stem. They are of transitional type representing both conditions. The vascular strand for the scutellum instead of passing immediately from the scutellar node to the scutellum, goes up to the base of the coleoptile and then turns downwards, after sending two branches to the coleoptile, till it reaches the scutellar node where it passes into the scutellum.

Anatomical comparison of the junctura region of a normal leaf with the corresponding region of a mutant leaf, without auricle, ligule and junctura.—The mutant leaves of the variety *shala* do not develop auricle, ligule and junctura. In a normal leaf, the junctura region consists of the mid-rib only without any wings. The ligule is an outgrowth of the epidermal cells of the ventral surface of the leaf-sheath. Anatomical observations show that in the mutant leaf, the cells that ultimately give rise to ligule is present in its proper place, but due to the absence of the junctura these do not develop as a free structure but is fused with the ventral surface of the leaf-blade. Due to the absence of the junctura and the free ligule the auricle could not develop.

Stem anatomy of the neutron induced dwarf mutant.—In a normal plant the internodes have two concentric rings of bundles and the parenchymatous cells gradually increase in size from the epidermis towards the pith. The air chambers, when present, are arranged in a ring. In the case of the neutron induced dwarf mutant in the variety *As. 35* the vascular bundles, the air chambers and the parenchymatous cells are arranged irregularly.

Rachilla-Spikelet transition.—Serial microtome sections from the rachilla to the middle of the spikelet were cut and studied for the structural development. Just at the base of the spikelet the first glume separates from the mother axis and then the 2nd glume. At this stage the mother axis assumes a roundish form. In the next stage the lemma and the palea separate. The first stamen which gets separated from the mother axis is placed towards the palea and not towards the lemma as has been reported by Arber (1934). The two lodicules are the last to separate and they are placed towards the lemma.

X. Collection and identification of rice weeds:

Several species of weeds have been commonly found growing in the rice field and also along the bunds. Some of them are seasonal and others perennial. No attempt appears to have been made in the collection and identification

of these weeds. Information regarding these weeds would be useful in the study of blast and insect problems. During the period under review the following weeds have been identified and preserved as herbarium for reference:

Name of the weed	Family
1. <i>Panicum crusgalli</i>	Gramineae
2. <i>Panicum ramosum</i>	do.
3. <i>Panicum colonum</i>	do.
4. <i>Paspalum sanguinale</i>	do.
5. <i>Paspalum disticum</i>	do.
6. <i>Eragrostis pilosa</i>	do.
7. <i>Setaria glauca</i>	do.
8. <i>Cynodon dactylon</i>	do.
9. <i>Cyperus rotundus</i>	Cyperaceae
10. <i>Cyperus haspan</i>	do.
11. <i>Cyperus iria</i>	do.
12. <i>Fimbristylis milleacea</i>	do.
13. <i>Commelina axillaris</i>	Commelinaceae
14. <i>Aneilema</i> sp.	do.
15. <i>Ludwigia parviflora</i>	Onagraceae
16. <i>Phyllanthus niruri</i>	Euphorbiaceae
17. <i>Phyllanthus simplex</i>	do.
18. <i>Leucas aspera</i>	Labiatae
19. <i>Melochia corchorifolia</i>	Sterculiaceae
20. <i>Vandellia crustacea</i>	Scrophulariaceae
21. <i>Ipomoea reptans</i>	Convolvulaceae
22. <i>Sphenoclea zoylanica</i>	Campanulaceae
23. <i>Justicia simplex</i>	Acanthaceae
24. <i>Eclipta alba</i>	Compositae
25. <i>Aponogeton monostachyon</i>	Naiadaceae
26. <i>Imperata arundinacea</i>	Gramineae
27. <i>Mnesittha perforata</i>	do.
28. <i>Kyllinga triceps</i>	Cyperaceae

XI. *Jeypore Botanical Survey Scheme:*

Survey and Collection.—During the years from 1958-60 parts of Jeypore tract consisting of Papadahandi, Rayagada, Bissam-Cuttack and Gunpur taluks, South Raipur consisting of Dhamatari and Brindanawagad taluks, the Bastar district consisting of Kankar Kondagaon, Narayanpur, Jagadapur, Dantewada, Konta, Bhanupratapur and the Kalahandi district of Orissa consisting of Bhavanipatna, Dumarapur and Ampani were surveyed. Six hundred ninety four cultivated types (*O. sativa*) and 52 wild types (*O. sativa* var. *spontanea* & *O. perennis*) were collected from these and the adjoining forest areas. Special mention may be made of a double grain variety and a new species of *Oryza* (tentatively named as *O. jeyporensis*) which are included in the collection.

Botanical studies.—(1) *Grain size.*—The seed samples were measured for their grain size. According to their length 73 samples are very short, 79 short, 285 medium, 215 long and 37 very long. Based on breadth, the samples were grouped into 52 narrow, 187 medium and 455 broad-grained types.

(2) *Shape Index.*—Assuming a L-B ratio greater than 3 to be oblong and less than 3 to be oval the collection includes 188 oblong and 506 oval grained types.

As many as 34 samples whose L-B ratios were 2 or less were found to have round bold grains comparable to the *Japonica* type of grain. Some of these varieties were compared with 2 *japonicas* (grown during the second crop season) in respect of (1) number of ear heads per plant (2) length of the ear-heads (3) mean no. of grains per ear-head (4) weight of 1000 grains and (5) length, breadth and shape index (L-B ratio) of the spikelets. It was found that except for the length of the ear-head there were no significant differences in the means of other characters between these types and the true *japonicas*. Study of F_1 's between these types and the *japonicas* and some *indicas* revealed 35 to 75% spikelet sterility in the former and 20-25% in the latter.

(3) *Awn.*—Of the 696 samples collected eighteen samples were found to be fully awned, 38 partly awned or awntipped and the rest awnless. A detailed study of the character and degree of awning undertaken during 1960 of the entire collection indicated that out of total of 307 awned types 97 are fully awned, 101 rarely awned, 36 awntipped and 78 rarely awntipped.

From experiments conducted during the second crop season, some of the early and medium duration awned types were found to be photo-insensitive.

(4) *Miscellaneous characters of genetical interest.*—The collection from Jey-pore tract during this period includes 5 glutinous types, 14 varieties with long sterile glumes, 25 scented types, 5 clustered and one double grained variety.

Duration.—Duration was determined for 482 varieties. 59 varieties were early, 360 medium and 43 late.

Grading.—Taking into account the L-B ratio and volume of 1000 grains 477 samples were graded into 7 categories. Accordingly, 85 are oval fine, 170 oval medium, 82 oval bold, 63 elongated fine, 54 elongated medium, 14 elongated bold and 9 elongated and very fine.

Colour of lemma and palea.—The colour of lemma and palea at flowering and at ripening was recorded according to available standard colour charts. The grouping of ripening colour resulted in 18 primary colour classes and 33 intergrades.

Other studies:—

Panicle density.—The length and density of the panicle varied greatly in the different varieties. The length of the ear-head varied in this collection from 16 to 36 cms. Many of the long panicles are lax, with sparsely arranged spikelets. Dense panicles have been found to have short, and small grains indicating some correlation between these characters. J.B.S. Nos. 290, 344, 1108, 1128, 1134 and 1164 are some of the short, dense-panicked types, while J.B.S. Nos. 431, 437, 484, 535, 932, 1140 and 1176 are some of the long, dense-panicked types.

Morphological studies.—Colour of the coleoptile was observed during the seed-bed stage in all the varieties. In 335 varieties, the coleoptile was found to be pigmented.

Varietal trial.—A trial, involving 15 early-duration types (110 to 120 days) was conducted to find out their yield capacity. N. 136 (local Orissa strain) was used as the standard.

The analysis of data showed that J.B.S. 152, 238 and 601 yielding respectively 1716, 1714, 1532 lb. per acre were significantly superior to the standard N. 136.

Upland trial.—In a trial conducted in collaboration with the physiologist some of the early varieties collected in this Scheme were tried under upland, rain-fed conditions during the maincrop season.

No variety yielded more than B. 76-114 which gave yield of 2352 lb. per acre.

Study of wild types.—Among the *O. perennis* types collected, a variety which purple leaves was isolated, a feature which has not been recorded so far in these wild types. The pigmentation is deep at the tip and margin of the blade and gradually fades as it spreads towards the mid-rib.

Cytological examination was made of some of the wild types by way of smearing the pollen mother cells. The 2 N number of the local *O. perennis* var. *balunga* is 24. During meiosis, normally it forms 12 bivalents but occasionally forms ten bivalents and a quadrivalent. In spite of the quadrivalent formation, the separation of the chromosomes to daughter cells is normal in most cases so that the fertility is not affected much.

Several crosses were made to study hybrid vigour.

XII. Cytology:

Origin and evolution of cultivated rice.—In the progeny of an inter-varietal hybrid of *O. perennis* (*O. p. cubensis* × *O. p. balunga*), plants resembling cultivated rice were observed, and selection on that basis has been carried forward to F_6 generation. The results showed that variability within the species *O. perennis* could be utilised in the production of plants resembling cultivated rice and also gives an indication of the role of variability in the origin of cultivated rice.

To elucidate the utility of *javanica* subspecies of rice, in rice breeding for India, a cross between a *javanica* variety (Baok), and an *indica* variety from borneo, (Bontar) had been made. The F_2 population contained plants having stiff straw as well as dense long panicles. Selections have been made to secure a productive variety with these features and the F_6 generation is to be grown.

Interrelationship of species of genus, Oryza.—The new accessions to the species collection were the following: a wild species from Dangs area of Gujerat, *O. subulata*, *O. grandiglumis*, a new variety of *O. perennis* from Sudan and a new variety of *O. ridleyi* from Malaya. The species from Dangs region resembled *O. officinalis*, in some characters, and a detailed study suggested that it could be a new species. *O. subulata* from South America had the chromosome

number $2n=24$ and was strikingly different from the rest of *Oryza* species in leaf and spikelet characters, but resembled members of another genus, *Lizaniopsis*. *O. grandiglumis* also from America was found to be closely related to *O. alta* and *O. latifolia* and differs from them mainly in having long sterile glumes. *O. ridleyi* sent by T.K. Van of Malaya was reported by him as having the chromosome number of $2n=24$ but one cytological examination here, the number was found to be 48 (a tetraploid) and not a diploid.

Genom analysis in section *Sativa* was completed. It is concluded that the Species *O. sativa*, *O. glaberrima*, *O. perennis*, *O. breviligulata* and *O. stapfii* have partially homologous genomes and the interspecific hybrids within the section showed normal chromosome pairing. The African species *O. glaberrima* *O. breviligulata* and *O. stapfii* are somewhat different from the Asian species as shown by hybrid sterility. The species *O. australiensis* had formerly been included in section *Sativa*, but the hybrid *O. sativa* $\times$ *O. australiensis* was completely sterile, with no homology between the genomes of the two species. Morphological characters suggest that it is intermediate between sections *Sativa* and *Officinalis*. (Fukoku $\times$ Babar). Previously similar haploid and tetraploid plants had been picked out from *japonica* $\times$ *indica* hybrid progenies. The present example confirms that *japonica* $\times$ *indica* hybrid progenies are a source of chromosome variants. The haploid plant was sterile and had reduced plant parts as expected. Fertile homozygous diploid sector was obtained from these culture during vegetative propagation. The haploid plants were used in a study of radiation biology. Stubbles treated with 2000 r units from a Gamma source failed to survive. Stubbles treated with 1000 r units are being multiplied and used for securing homozygous mutants.

A mixoploid was isolated from a population of T.1242 and the meiosis in this variant showed that both 24 and 36 chromosomed cells are present in the anthers.

Amphidiploids through colchicine treatment were obtained from F_1 hybrids of *O. sativa* $\times$ *O. glaberrima* and *O. sativa* $\times$ *O. breviligulata*, the former with 20-30% fertility and the latter with 3 to 5% fertility. This difference in fertility is inferred to be due to genic or cytoplasmic factors since the chromosome pairing at meiosis in the two F_1 hybrids and in the two derived tetraploids were similar.

A tetraploid sector was isolated from the F_1 of *O. sativa* $\times$ *O. australiensis*, after colchicine treatment of stem buds. This sector was also completely sterile and failed to survive. The sterility of the tetraploid sector was unexpected as only fertile amphidiploids are usually obtained. The experiment is being repeated.

Similar colchicine treatments for chromosome doubling is being done for the other intersectional diploid and triploid hybrids.

Mutation genetics.—In chemical mutagenesis, coumarin was tried in 1958, being applied at germination to a *japonica* $\times$ *indica* hybrid extract. (G.E.B. 24 $\times$ Norin 1). The population had many high yielding plants with slight variation in vegetative characters, and some of the plants were stiff strawed.

Three single plants were selected from the 1st generation (AB&C) and subsequently in a small scale field experiment the average single plant weight of each of these 3 progenies was found out to be 62, 57 and 48 gms. respectively for the progenies A, B & C. These are considered as promising yields.

A long term project has been started in the use of ionising radiation for increasing variability in pure strains of rice and for securing chromosome variants. Progenies of X-Ray irradiated Ch. 45 and neutron-irradiated As. 35 are being grown. Variability in X-2 onwards increased as expected. Selections were also made for semi-sterility, as these cultures after reaching homozygosity could be tested for the nature of chromosomal changes induced by the treatment. A dwarf mutant with thick leaves and partially fertile panicles was isolated from N_3 generation of the neutron irradiated As. 35, and on cytological study it proved to be a chromosome structural variant without any change in the diploid number, ($2n=24$) and it was also breeding true. Stubbles of 3 sterile interspecific hybrids (F_1) namely *O.sativa* $\times$ *O.eichingeri*, *O.sativa* $\times$ *O.alta* and *O.latifolia* $\times$ *O.minuta* were treated with gamma rays (at World Agriculture Fair, January, 1960) the former two crosses receiving 2 treatments each of 2000 r & 4000 r and the latter, 2 treatments of 3000 r & 5000 r. Some of the external effects observed included: Chlorophyll-deficient leaves in *O.sativa* $\times$ *O.eichingeri*, altered photoperiod response, and stigmatic anthers with feathery tips in *O.latifolia* $\times$ *O.minuta*. Apart from these, seeds of three wild species, viz., *O.perennis* var *Barthii*, *O.stafpii* and *O.australiensis* were treated with the gamma rays. The X_1 generation has been grown but sterility has prevented growing X_2 in *O.perennis* and in *O.australiensis*.

Genom analysis in the section *Officinalis* is underway, and a number of interspecific hybrids have been produced. The three American tetraploid species *O.latifolia*, *O.alta* and *O.grandiglumis* are inferred to have homologous pairs of genomes. This homology has been confirmed for the first two of these three, by study of meiosis in the F_1 hybrid and by analysis of morphological characters in F_2 plants. The third species *O.grandiglumis* has been crossed with the first two. By crossing *O.alta* and *O.officinalis*. It was confirmed that, of the two genomes of the former, one is homologous with that of *O.officinalis*. Similarly a tetraploid Indian species *O.malamfuzhiensis* has been found to carry one genom homologous with that of *O.officinalis*. An intersectional hybrid *O.sativa* $\times$ *O.alta* was completely sterile and there was no pairing of chromosomes at meiosis in the F_1 hybrid.

One intra sectional hybrid *O.sativa* $\times$ *satafpfi* was highly sterile but a small F_2 population could be raised. This population showed segregation for characters differentiating the two parental species.

Chromosome variants in rice.—Spontaneously occurring triploid was isolated from a culture of T.1242 (an improved strain of Orissa) and cytogenetic studies of the triploid T.1242 and its progeny are in progress with a view to isolate and identify the aneuploids and also to establish standard trisomics. Work on karyomorphological analysis of the *indica* subspecies is underway.

A haploid plant with the somatic chromosome number 12 was isolated from F_3 population of *japonica* $\times$ *indica* hybrid

XIII. Saline Resistant Rice Research Station, Port Canning :

Several varieties known to be saline resistant and collected both from the Genetic Stock at Cuttack and also from several states were grown for preliminary observations.

A programme of crossing was initiated and SR. 26B, a salt resistant type was crossed to some of the local *spontanea* types.

Several known green manure types were grown to select the promising ones for saline tracts.

Soil samples were collected from the different saline patches for chemical analysis to determine the salt content.

Chemistry

The work reported below was conducted during the period June 1958 to December 1960. The main interest of research in the Agricultural Chemistry Division has been fundamental studies on the Chemistry of rice soils and nutrition of rice plant and application of results obtained from these studies in field manurial trials. Much stress has been laid on the Nitrogen problem of rice soils and crop. Preliminary investigations have also been started on phosphate and potash problems. Studies on the genetics of high Nitrogen response in *indica Japonica* cross have been initiated by the Director in collaboration with the Agricultural Chemistry Division.

I. Investigations on nutrient availability in Water-logged soils, in relation to plant growth:

Studies, started during 1957-58 on the availability of nitrogen under water-logged soil condition were continued in 1958-59, at two different locations under medium and low land conditions, with medium duration (T.141) and late duration (T.1242) varieties respectively. This year the fertilizer was applied at planting, as compared to last year, when fertilizer was applied about 25 days after planting. Soil and plant samples were analysed at periodical intervals. The results obtained are summarised in the table given below.

As reported in 57-58 differences in the Ammonium nitrogen content of the soil, with increasing nitrogen treatments, could be detected easily only upto a period of about 30 days after application of fertilizer. At later stages these differences were not marked and therefore could not be detected easily.

Results showed that highest yield response was obtained in treatments showing nitrogen content of 30 ppm. 15 days after planting and 10 ppm. 30 days after planting in the medium land soil. Higher nitrogen content was detected in soil with increasing levels of nitrogen applications, but the yield obtained at nitrogen levels higher than 40 Kg./Ha. was statistically at per. In the lowland soil however the highest yield response was associated with nitrogen content of soil at 22 ppm. 15 days and 14 ppm. 30 days after planting.

TABLE XXXIX

NH₄-N content of soil with increasing levels of nitrogen application

Sl. No.	Nitrogen level Kg./Ha.	Medium land soil				Low land soil			
		NH ₄ -N ppm./days after fertilizer application			Grain yield Kg./Ha.	NH ₄ -N ppm./days after fertilizer application			Grain yield Kg./Ha.
		15	30	45		15	30	45	
1.	0	5.5	6.0	2.0	2334	8.9	7.1	4.5	2230
2.	20	14.0	8.5	2.5	2532	15.3	10.8	6.5	2857
3.	40	29.5	10.2	2.8	3195	22.4	14.0	8.8	3257
4.	60	59.7	13.0	3.8	3463	24.9	21.4	15.0	3263
5.	80	64.7	21.0	5.8	3663	..	..	..	..
6.	100	77.7	42.2	6.5	3276	..	..	..	..
	C.D. at 5% Kg./Ha.				541				223

Nitrogen content of the plant was also examined at periodical intervals at corresponding stages of growth and also at later stages upto maturity. It was seen that nitrogen content of plant continued to increase with increase in level of nitrogen application at all stages of growth and that the differences in nitrogen content were highly marked up to 60 days after fertilizer application. Nitrogen content of plant, about 2.5%, for both medium duration (T.141) and late duration (T-1242) varieties at about 30 days after planting and fertilizer application was adequate for optimum yield response.

To determine the reserve nitrogen in the plants, tissue tests were also tried. A simple chromatographic method was developed to determine glutamine and asparagine content in the young growing leaf in the main tiller. The study of tissue testing procedures for reserve nitrogen will be continued next year and different parts of the plant be tried for estimation of reserve nitrogen in the plant.

II. Influence of soil water on plant growth and Nitrogen uptake :

Influence of soil-water and nitrogen on plant growth was investigated in pot experiments with rice varieties Ptb. 10 (short duration), T.141 (medium duration) and BAM. 9 (long duration) during the main crop season 1958-59 and with variety Ptb. 10 (short duration) only during the second crop season.

(i) In trials with three varieties during the main crop season, influence of continued flooding of the soil even after flowering was compared with keeping the soil moisture at 70-80 % of field capacity, after flowering. Plant samples were also analysed at the stage, when flooding was withheld and later at 15 days interval till maturity.

Results show that soil moisture at 70-80% of field capacity after flowering was adequate for yield and nitrogen uptake by rice plant and that flooding beyond flowering was not necessary as far as uptake of nitrogen and grain yield were concerned.

(ii) During the second crop season, flooding was stopped at 15, 30, 45, 60 and 75 days after planting, and soil moisture at later stages was maintained at about 70-80% of field capacity. These treatments were compared with continued flooding and with 70-80% of field capacity upto maturity. The data are given in the Table XL.

TABLE XL

Influence of flooding on yield and nitrogen uptake by rice variety Ptb. 10

Sl. No.	Treatment	Ear heads per pot	Straw gm/pot	Grain gm/pot	Wt. of 1000 grain	No. of set grain per panicle	N. content of grain
1.	Flooded upto maturity	37.5	53	65.1	23.13	75	1.15
2.	70-80 percent field capacity upto maturity.	37.7	44	47.7	21.76	59	1.32
3.	Flooded for 15 days 70-80 percent field capacity later.	38.5	44	53.6	22.18	63	1.21
4.	Flooded for 30 days and 70-80 percent field capacity later.	44.8	52	58.7	22.05	60	1.22
5.	Flooded for 45 days and 70-80 percent field capacity later.	38.3	50	67.3	22.91	76	1.17
6.	Flooded for 60 days and 70-80 percent field capacity later.	45.5	52	73.5	22.88	70	1.10
7.	Flooded for 75 days and 70-80 percent field capacity later.	47.0	51	71.0	22.92	65	1.15
8.	Flooded for 15 days and then 70-80 percent field capacity upto 45 days and flooded later.	39.0	50	51.8	22.20	66	1.20

C. D. for comparison of grain yield 9.7 gram.

It is seen from the data that flooding of soil up to 45-60 days of growth after planting was essential for increasing grain yield. Withholding of flooded conditions at any period prior to this stage had adverse effect on yield. Withholding of flooded condition after 60-75 days of planting also gave a slightly higher grain yield than continuous flooding upto maturity. The lower grain yield in the treatments 2 and 3 in the above table was mainly due to decrease in panicle weight caused by decreased weight of 1000 grain and fewer number of set grain per panicle.

Per cent nitrogen in the grain on the other hand was highest in the treatment in which moisture was maintained at 70-80% of field capacity throughout the growth period of the crop.

III. Rapid tissue test to determine the need or otherwise of nitrogen top dressing to rice:

A number of plant tissue testing procedures were tried during the year 1959-60 to find a simple and rapid method for determining nitrogen status of growing plants in order to determine the need of fertilizer application at specified growth stages.

Nitrogen was determined in plant tissue by various methods in a replicate trial in which graded levels of nitrogen up to 100 Kg./Ha. were given.

In this study a simple chromatographic method was developed to determine the nitrogen reserve in the growing plant. The cell sap from the basal part (1-3 cm from base) of the main tiller was transferred by means of a pair of pincers on to the centre of a filter paper and a circular chromatogram run in butanol 4 parts, Acetic acid- 1 part and 10% Ninhydrin solution in water- 1 part. Five to seven examinations were done from one area to be tested. The extent and the intensity of the chromatogram thus obtained was taken as an index of nitrogen reserve in the plant tissue. Six grades of nitrogen status were recognised on the basis of the chromatograms and at 20-30 days' of growth after planting. By this method the nitrogen status was determined. The crop which was adjudged to be deficient in nitrogen, fertilizer application was given. The growth and yield of the crop in the different treatments are given in the table below :

TABLE XLI

Results of tissue testing and its relation to nitrogen need for increasing yield

Grade	N Kg./Ha.	Colour intensity in chromatograph	Fertilizer need foretold/Ha.	Grain yield Kgm./Ha. with observed additional application of fertilizer	Yield with additional 20 Kg. than nitrogen
1	Nil	Very low	40-60 Kg.	1320	
2	20	Low	20-40 Kg.	1989	2586
3	40	Medium	10-20 Kg.	2671	2919
4	60	High	Nil	3241	
5	80	Very high	Nil	3596	
6	100	Extremely high	Nil	3083	

Results show that need and amount of fertilizer application can to a large extent be detected by this simple chromatographic method at 20-30 days growth after planting.

IV. *Utilisation of applied nitrogen by rice crop from different nitrogen carried in relation to time of application:*

(a) Studies on utilization of fertilizer nitrogen by rice crop from Ammonium sulphate, Ammonium nitrate and urea, in relation to time of application of the fertilizers were undertaken in pot experiments with the variety T.141 during the 1958-59 main crop season and variety Ptb. 10 during the second crop season. Single dose of fertilizer application at 100 gram nitrogen per pot containing 15 Kg. soil was given, either basal at planting or at intervals of 15 days after planting in the case of variety T. 141 (medium duration) and 10 days after planting with variety Ptb. 10 (short duration). In each case fertilizer was

well mixed with soil with minimum quantity of surface water in pots and flooding of pots was done at 12-24 hours after fertilizer application. The data obtained are shown in the following Tables:

TABLE XLII
Influence of application of Nitrogen fertilizers on yield
Variety T. 141—Main season crop
No. manure yield—38.5 gm./pot

(Yield in gram per pot)

Fertilizer	Time of application—Days after planting								Mean
	0*	15	30	45	60	75	90**	105	
Ammonium sulphate	72.8	85.8	86.2	83.0	79.7	73.8	51.2	44.4	72.1
Ammonium nitrate.	63.0	70.9	73.5	69.7	67.0	64.5	49.1	44.5	62.7
Urea .	83.1	90.5	96.2	88.8	83.2	72.2	55.1	45.4	76.8
MEAN .	73.0	82.4	85.3	80.5	76.6	70.2	51.8	44.8	..

C. D. for comparing individual treatment mean—6.4

C. D. for comparing of application mean—3.7

C. D. for comparing fertilizer mean—2.3

*20 days' old seedlings were planted.

**Booting stage of crop.

TABLE XLIII
Influence of time of nitrogen application on yield
Variety Ptb. 10—2nd Season crop
No manure yield—27.5 gm. per pot

(Yield in gram per pot)

Fertilizer	Time of application—Days after planting								Mean
	0*	10	20	30	40	50**	60	70	
Ammonium sulphate.	62.3	67.9	71.9	65.1	62.0	36.9	27.6	26.3	52.5
Ammonium nitrate	49.0	60.6	58.7	57.5	49.8	39.6	26.2	28.0	46.2
Urea .	75.7	***	62.5	67.8	61.8	39.8	26.0	24.2	51.1
MEAN .	62.3	64.2	64.4	63.5	57.8	38.8	26.6	26.1	..

C. D. for comparing individual mean . . . 7.7

C. D. for comparing time of application mean . . . 5.5

C. D. for comparing fertilizer mean . . . 2.9

*20 days' old seedlings were planted.

**Booting stage of crop.

***Pots under the treatment were damaged.

It is seen from the above two tables that for a medium duration variety T.141, grown in the main season (July-December) application of nitrogenous fertilizer can be done up to about 95 days of growth inclusive of growth in the seed bed. Application of nitrogen after this period had very little effect in increasing yield. During this period of 95 days from sowing, greater fertilizer efficiency was obtained if fertilizers were applied within about 65 days of sowing.

In the case of early duration variety, Ptb. 10 grown during the second crop season, the optimum period of application of nitrogen fertilizer was upto 60 days after sowing.

Amongst the fertilizers tried Ammonium nitrate on an average gave significantly lower response than Ammonium sulphate and urea in both the seasons. During the main crop season on the other hand urea, on an average, gave better response than Ammonium sulphate.

The interaction of type of fertilizer and time of application was also significant. It was seen that Ammonium nitrate applied 10-20 days after transplanting gave better response than that applied at the time of transplanting.

The total quantity of fertilizer nitrogen used by crop with different times of application was same with Ammonium sulphate and urea, but was considerably less with ammonium nitrate.

Soil culture studies on utilization of nitrogen fertilizer when applied as Ammonium sulphate, Ammonium nitrate and urea started during (—) 1958-59 were continued in 1959-60. This year the influence of split application, with one dose given basal at planting and other at periodical intervals after planting was investigated with variety T.141 during the main crop season and variety Ptb. 10 during the second crop season. The results of two trials are given in the following tables:—

TABLE XLIV

Influence of split application of nitrogen Fertilizer on crop yield

Main crop season—Variety T. 141

No. nitrogen yield—40.2 gms/pot.

(Mean yield in gram per pot)

Sl. No.	Treatments	Ammonium sulphate	Ammonium nitrate	Urea	Mean
1.	1 gm. N per pot basal at planting	70.8	61.2	84.5	72.2
2.	0.7 gm. N per pot basal at planting	59.3	48.0	53.7	53.7
3.	0.7 gm. N basal + 0.3 gm. N 20 days later.	72.8	58.4	78.4	69.8
4.	0.7 gm. N basal + 0.3 gm. N 40 days later.	67.1	66.8	74.5	69.5
5.	0.7 gm. N basal + 0.3 gm. N 60 days later.	69.7	67.0	67.0	67.9
6.	0.7 gm. N basal + 0.3 gm. N 80 days later.	67.5	59.2	59.9	62.2
MEAN		67.9	60.1	69.7	

C. D. for comparing fertilizer mean 4.5

C. D. for comparing nitrogen application 6.3

C. D. for comparing individual mean 10.8

TABLE XLV

Influence of split application of nitrogen fertilizers on crop yield

Variety Ptb. 10—2nd season crop

No. nitrogen yield—55.8 gm.

[Mean yield gm. per pot]

Sl. No.	Treatments	Ammonium sulphate	Ammonium Nitrate	Urea	Mean
1.	1 gm. N basal at planting . . .	86.1	76.3	89.5	84.0
2.	1 gm. N 20 days after planting . .	93.5	75.9	82.1	83.8
3.	0.7 gm. at planting 0.3 gm. 20 days later.	90.0	80.2	84.9	85.0
4.	0.7 gm. N at planting 0.3 gm. 40 days later.	93.5	75.6	92.0	87.0
5.	0.7 gm. N at planting 0.3 gm. 60 days later.	85.3	71.1	84.8	80.4
6.	0.4 gm. N at planting, 0.3 gm. 20 days later, 0.3 gm. 45 days after planting .	94.2	77.0	89.9	86.5
MEAN		90.1	76.0	87.2	

C. D. for fertiler means . . . 2.4

C. D. for nitrogen treatment . . 3.4

C. D. for individual treatment mean 5.8

It was seen that in T.141 the second split given over basal application viz. 20, 40 and 60 days interval after planting had no effect on grain yield. On the contrary split application with second dose given 80 days after planting with T.141 reduced grain yields significantly. In the second crop season also, there was no significant effect of split application over basal dose, where the results averaged over the three fertilizer are compared, but application of ammonium sulphate 20 days after planting was significantly higher than application at planting. Some of the split applications were as good as application 20 days after planting.

Split application with second dose given 80 days after planting in T.141 and 60 days after planting in Ptb. 10 had significantly reduced the yield.

(b) Studies were also undertaken in 1958-59 main crop season to find out the time of application of urea for obtaining the maximum response in yield in comparison with Ammonium sulphate. In this study urea and sulphate of ammonia were applied at intervals of 7, 4, 2 and 1 day before flooding and

puddling and were compared with usual application after flooding and puddling of soil. Nitrogen application of 1 gram per pot was given and each pot contained 18 kgm. of soil. Results are given in the following Table:—

TABLE XLVI
Influence of time of fertilizer application on crop yield

No. manure yield—49.5 gm./pot

(Yield in gram per pot)

Fertilizer	Fertilizer applied—days before flooding and puddling					Mean
	7	4	2	1	0*	
Ammonium Sulphate	86.3	94.2	96.1	91.6	89.1	91.5
Urea	88.4	88.0	91.0	94.1	83.5	89.0
MEAN	87.3	91.1	93.5	92.8	86.3	

C. D. for comparing individual treatment mean 8.2 gram

C. D. for comparing time of fertilizer application 5.7 gram

*Crop was planted immediately after puddling.

From the above table it is seen that application of Ammonium sulphate and Urea 1 and 2 days before flooding and planting gave significantly higher response in yield than application after flooding and puddling. The interaction between fertilizers and time of application was however not significant. In the case of urea the maximum response was obtained when it was applied 1 day before puddling and the yield differences with urea applied 4 days before puddling and the 2 & 1 day treatments were not significant. The experiment was repeated with same line in 1960 main crop and similar trends in result were obtained.

(c) Fertilizer trials have been in progress at the Institute to determine the suitable time of application of urea. The treatments which have been studied relate to planting and post planting periods. During the year 1959-60 trials were started to try the effect of application of urea and Ammonium sulphate prior to planting. Application of fertilizer on yield response in two periods *viz.* one day prior to planting and four days prior to planting were compared with the usual treatment *viz.* application at planting and application a month after planting. The two fertilizers, urea and Ammonium sulphate were tried

at 40 Kg. N/Ha. The variety used was T.1242 of 160 days duration. The results obtained are given in the following table.

TABLE XLVII

Influence of time of application of nitrogen fertilizer on grain yield of rice

(Grain yield in Kg./Ha.)

Sl. No.	Treatment	Ammonium sulphate 40 Kg. N/Ha	Urea 40 Kg. N/Ha.	Mean
1.	Application at planting	2911	2863	2887
2.	Application one month after planting	3152	3175	3163
3.	Application with final puddling, one day before planting.	3049	3086	3068
4.	Application with preliminary puddling 4 days before planting.	3400	3261	3330
MEAN		3128	3096	

C. D. for comparing time of application . 265 Kg./Ha.

It might be seen that application of fertilizer at preliminary puddling, four days before planting gave higher response of 15% more grain yield than application at planting. The difference between other treatments were not significant. Both the fertilizers gave a similar response to the time of application. Perhaps the application of fertilizer four days before planting and at the time of preliminary puddling results in the fertilizer getting ploughed down in the furrow slice, where it remains relatively stable. The experiment was repeated in the identical manner during main crop season 1960 and similar trend in result were obtained.

(d) The effect of application of nitrogen at ear initiation stage in increasing yield was studied with eight rice varieties of late duration (150-165 days). The fertilizer (Ammonium sulphate) was applied in 30, 60 and 90 kg. per ha. either as a single application at planting or split application at planting and

about 15-20 days before earing. Results obtained are given in the following table:

TABLE XLVIII
Influence of nitrogen top dressing on grain yield of rice

(Mean yield in Kg./Ha)

Sl. No.	Variety	Nitrogen level						Mean
		Control	30-0	30-30	60-0	60-30	90	
1.	AC. 1951 . . .	1686	2186	2732	2441	2273	2527	2308
2.	T.1242 . . .	1705	2045	2227	2314	2905	2518	2286
3.	T.90 . . .	1277	2277	1864	2114	2127	2114	1962
4.	BAM.9 . . .	1891	1955	1995	2073	2309	1823	2008
5.	BAM.6 . . .	2095	2245	2736	2632	2736	2709	2525
6.	Salak . . .	1118	1368	1350	1345	1445	1691	1386
7.	Untung . . .	1609	1723	1500	1909	1664	1900	1717
8.	W.24 . . .	1627	1955	2395	2105	2573	2545	2200
MEAN		1626	1969	2100	2117	2254	2228	

C. D. for nitrogen mean 286

C. D. for variety mean 176

C. D. for variety mean with nitrogen treatment 430

C. D. for nitrogen mean within a variety . . . 491

C. D. for control V/S N mean 222

These trials were linked up with tissue testing procedures to determine the need for top dressing at later stage of growth *i.e.* 15-20 days before earing. Tissue test at various stages of growth were performed on the newly developed leaf on main tiller before booting and presence or absence of asparagine in the leaf sap of different varieties was determined by circular paper chromatography, but asparagine test could not be correlated with need or otherwise for top dressing.

V. Testing of urea forms as a fertilizer for rice:

(a) Sixteen urea-form products, having U/F ratios of 1.5, 2.0, 2.5 and 3.0 respectively were prepared using four different catalytic agents. These products were tested under pot experiments as nitrogen suppliers for rice and were compared with ammonium sulphate and urea during the second crop season 1958-59. The early duration variety, Ptb. 10 was used in the trial and

fertilizers were given as basal dressing at 1.0 gram nitrogen per pot. The data on grain yield obtained with different treatments are given in the following Table :—

TABLE XLIX

(Grain yield in gram per pot)

Sl. No.	Fertilizer	U/F Ratio	Grain/pot	Yield gram/pot			
				Catalyst used			
				Sulphu- ric acid	Phospho- ric acid	Oxolic acid	Nitric acid
1.	Control	..	32.3				
2.	Amm. Sulphate	..	66.7				
3.	Urea	..	68.1				
4.	Urea form (control)	..	51.8				
5.	Urea form 15	1.5		39.4	53.5	59.2	55.2
6.	Urea form 20	2.0	..	52.6	58.9	62.5	52.1
7.	Urea form 25	2.5	..	69.3	64.8	..*	62.2
8.	Urea form 30	3.0	..	56.9	66.7	51.5	54.6

It is seen from the data that urea form 20 (Oxolic acid) and urea form 25 (sulphuric acid, phosphoric acid and nitric acid) and Urea form 30 (Phosphoric acid) give a yield response which were as good as the response obtained with sulphate of Ammonia or Urea.

Since Urea form products are slow acting fertilizers, their residual effect on crop yield was studied with the same variety Ptb. 10 planted after the harvest of the crop in the above experiment. It has been seen that none of the fertilizers left any residual effect.

(b) Three urea form products, obtained from Japan having U/F ratio of 1.5, 2.0 and 3.0 and one product obtained through Indian Council of Agricultural Research were compared with Ammonium sulphate and Urea as

fertilizer for rice in main crop 1959-60. All the fertilizers were used at 500, 750 and 1000 mg. nitrogen per pot containing 20 kg. of a dry soil. The results obtained are summarised in the following Table :

TABLE L
Influence of urea form fertilizer on yield of rice crop
(Yield in Gm. per pot)

Sl. No.	Fertilizer	Nitrogen level/pot			Mean
		500 mg.	750 mg.	1000 mg.	
1.	Ammonium sulphate	75.6	83.4	95.0	84.7
2.	Urea	80.8	78.5	88.3	82.5
3.	Urea form (I.C.A.R.)	57.5	70.1	72.0	66.5
4.	Urea form 1.5 Japan	71.2	58.6	77.7	69.2
5.	Urea form 2.0 Japan	65.9	70.5	73.2	69.9
6.	Urea form 3.0 Japan	67.2	80.0	91.0	79.3
MEAN		69.7	73.5	82.9	

C. D. for comparing individual treatment 10.5

C. D. for comparing fertilizer means 4.5

C. D. for comparing N level mean 3.2

It might be seen that urea form products of U/F ratio 3.0 were as good as sulphate of ammonia or urea at nitrogen level 750 and 1000 mg. per pot. Other urea form products of lower U/F ratio are inferior to these fertilizers. The results are in conformity with those obtained in the previous experiment.

From these studies it was concluded that Urea form products offer no special advantage as nitrogenous fertilizers for rice. The cost of these as compared to other fertilizers like sulphate of ammonia and urea was high, therefore, it is not economical to use these fertilizers for rice.

IV. Study of nitrogen assimilating capacity as a measure of high nitrogen response in *indica* × *japonica* crosses :

Fundamental studies on the genetics of high fertilizer response were initiated by the Director in collaboration with the Agricultural Chemist. In these studies one *japonica* × *indica* cross combination involving Norin 17 and Ptb. 10 was used. The parents and the F_1 hybrids were grown in culture solutions at different levels of nitrogen viz., 10, 20, 40, 60, and 100 ppm. The F_2 's were uniformly grown at one level of nitrogen (viz. 60 ppm N) and the general growth characteristics, yield attributes and nitrogen assimilating capacity were studied. Positive response for heavy manuring has been observed in these hybrids with increasing levels of nitrogen. The study is in progress.

VII. Growth and uptake of nutrients by Rice under different levels of N, P. and K.:

(a) Studies on growth and nutrient assimilation by rice variety T. 1242 from nitrogen, phosphate and potash fertilizers, conducted during the year 1957-58 were repeated at the same location during 1958-59 main crop season. The results obtained confirmed the findings regarding nitrogen uptake by the variety reported during 1957-58.

Nitrogen application alone or in combination with P & K gave significant increase in yield of grain. Phosphate and potash fertilizers alone or in combination with nitrogen fertilizer did not increase yield. Significant response due to nitrogen application was obtained upto 40 kg/ha. Response to nitrogen application was 31.3 Kg. of grain per hectare for each Kg. of nitrogen applied upto 20 kg. N/ha and 20 kg. grain/ha for each kg. of nitrogen for additional 20 kg. N/ha. No nitrogen yield was 2230 kg./ha.

Soil and plant samples from these trials were analysed at periodical intervals and results confirmed the findings of the previous years regarding nutrient uptake at different stages of growth.

(b) Two separate trials were laid out to study the fertilizer response in early duration variety Ptb. (110 days) under broadcast and transplanted conditions. Broadcast trial was entirely rain-fed and no irrigation was given during growth period while transplanted crop was grown as usual. Ammonium sulphate was applied at sowing with broadcast crop and at planting with transplanted crop.

Increase in yield was obtained in both cases with application of nitrogen fertilizer only. Phosphate application alone or combination with nitrogen had no effect on yield.

VIII. Foliar Diagnostic symptoms of Mineral Deficiency in rice :

Studies on foliar diagnostic symptoms in rice due to deficiency of Nitrogen, Phosphate, Potash, Calcium and Magnesium were undertaken during the second crop season 1958-59 with variety Ptb. 10 (short duration) grown under solution culture technique. Deficiencies were induced by suitably altering the composition of nutrient solution and records of deficiency symptoms were kept. Plants were first grown under normal conditions at 30 ppm N and 20 ppm each of P_2O_5 , K_2O , CaO and MgO and then put on deficiency levels.

The deficiency of nitrogen and potash resulted in acute reduction in growth and yield of crop. Complete absence of potash also gave extremely poor yield, but low level of potash as much as $1/4$ th the normal level had practically no influence on growth and yield. Deficiencies of Ca and Mg. also did not have much influence on growth; the deficiencies of these nutrients tended to give higher tiller number per pot but in spite of this, the grain yield was slightly reduced. Deficiency symptoms observed with lack of various nutrients was as under:

Nitrogen deficiency.—Plant has stunted growth, poor tillering capacity, short and narrow leaves. Colour of leaves is pale green. Old leaves die tip downward and the colour of dried leaves is orange yellow. In the initial stages side tillers are more affected than the main tillers. Primary roots are elongated root hairs are scanty and root growth is retarded. Colour of stem is pale green.

Phosphate deficiency.—Like N deficient plants P-deficient plants also have stunted growth, poor tillering capacity, short and narrow leaves. Older leaves dry up from top downward along the margin and the drying then spreads towards the mid rib. Colour of dried leaves pinkish yellow but top leaves have intense green colour tending to be bluish green. There is elongation of primary roots but the root hairs are scanty.

Potash deficiency.—Plants are stunted in growth but the tillering is not seriously effected, ear bearing tillers are however few. Old leaves die from tip downward along the leaf margin and colour of the dead leaves is dirty yellow with dark brown spots. Leaves are soft and swinging over. Primary as well as secondary roots are elongated and root hairs are few. Colour of the new emerging leaf is dark green.

Magnesium deficiency.—Plant height and the tillering capacity is not affected. Deficiency symptoms show up on the old leaves which die from tip downward along the margin. Deficiency symptoms on leaves are very much like potash hunger, except that drying pattern is more restricted towards the leaf margins. Leaf spotting as in the case of K-deficiency is also absent. Leaf angle with stem or leaf sheath is wider in Mg-deficient plant than in K-deficient plants or in normal plants. Root hairs are scanty and primary root is elongated.

Calcium deficiency.—No specific symptoms were observed in early stage except that very light N and P deficient symptoms were superimposed. Root growth was however affected primary roots were elongated and root hairs were few. At very late stage, the new leaf emerging in some of the Ca deficient plants had a slightly whitish green colour.

The experiment was repeated during the main crop season 1959-60 with a green variety T. 141 and a pigmented variety Ch.2. Deficiency symptoms of the different nutrients for the green variety were same as observed in the previous year. In the pigmented variety however the colour of deficient leaf was lighter than that of the normal level, but there was no marked difference in the colour of dried leaves under various deficiencies of marking of colour by the pigment.

IX. Studies on phosphate Nutrition of Rice Plant :

(1) *Partial efficiency of phosphate absorbed at different stages of growth of rice plant in relation to grain yield.*—(a) Studies were undertaken on partial efficiency of phosphate taken up by rice plant at different stages of growth in relation to increase in grain yield. Partial efficiency of phosphate uptake for formation of grain is defined as increase in yield of grain for unit increase in phosphate (P_2O_5) uptake. Trials were conducted with two varieties Ptb. 10 (short duration) and T. 141 (medium duration) in the main crop season 1958-59. Both varieties were grown at two levels of P_2O_5 , viz., 2ppm. P_2O_5 the deficiency level and 15 ppm. P_2O_5 the optimum level for plant growth. Phosphate treatment in respective pots was stopped at successive intervals of 10 days period till maturity. Influence of phosphate uptake on plant growth and yield was studied for phosphate supplied upto each treatment stage.

From the data obtained it was seen that both the varieties behaved almost in a similar manner as regards phosphate uptake. Ptb.10, the early duration variety showed a vigorous phosphate need for increasing grain yield, upto 30-40 days of growth after planting and later again at 70-80 after

planting. T. 141 the medium duration variety also showed two stages of vigorous phosphate uptake for increasing grain yield, one upto 50-60 days after planting and the second at 100-120 days after planting. These stages of maximum need of phosphate uptake in both varieties coincided more or less with tillering stage and grain setting stage, respectively.

(b) Studies on comparison of partial efficiency of phosphate uptake for production of grain by indica (ptb. 10) and japonica (Norin. 17) rice varieties were undertaken under solution culture technique during the second crop season 1959-60.

Phosphate application in pot was withheld at intervals of 10, 20, 30, 40, 50, 60, 70 and 80 days after planting and influence of phosphate taken up to these stages on grain yield was determined. All pots received normal level of other nutrients.

Due to adverse climatic conditions at flowering the grain did not set properly and as such no definite conclusions could be drawn regarding this variety. From the growth data however, it was seen that the phosphate requirements for growth were high after 10-40 days of growth after planting for the indica and japonica varieties.

These results compare well with results from experiment on time of application of phosphate fertilizer reported under (a).

(2) *Time of applications of phosphate to Rice.*—(a) Experiments were conducted under soil culture in pots to determine best time of application of phosphate fertilizer. Hitherto only basal application of super phosphate, rock phosphates and bone meal and others have been tried. In the present trial, fused Ca-Mg phosphate (sample obtained from Japan) was tried at intervals of 15, 30, and 45 days after planting during 1959-60 second crop season with variety Ptb. 10. The results are given in the following Table :

TABLE LI

Influence of time of application of phosphate fertilizer (Ca-Mg phosphate) in crop yield

No. Phosphate yield=63.7 gm/pot

(Mean yield in Gm/Pot)

Sl. No.	Fertilizer fused Ca-Mg Phosphate time of application	1 gm. P ₂ O ₅ /Pot	2gm. P ₂ O ₅ /Pot	Mean
1.	At planting	61.2	61.8	61.5 (100)
2.	15 days after planting	70.3	73.2	71.8 (117)
3.	30 days after planting	73.1	70.6	71.9 (117)
4.	45 days after planting	69.4	67.8	68.5 (111)
5.	½ at planting ½ 30 days after planting	77.8	76.2	77.0 (125)
	MEAN	70.4	69.9	

C. D. for comparing time of application mean 4.3

C. D. for comparing individual mean " 6.1

(b) The experiment was repeated during the main season crop 1960 with variety T. 141. Super phosphate of lime in addition to fused Ca-Mg phosphate was included in the study and the time of application was slightly modified. Results were summarised in Table below:

TABLE LII

Influence of time of applications of Super phosphate and fused Ca-Mg phosphate on grain yield of rice

Control yield 65.4 Gm/pot

(Mean yield in Gm/Pot)

Time of application	Yield Gm/pot	
	Superphosphate	Fused Ca-Mg. phosphate
At planting	67.9	65.6
20 days after planting	69.5	68.4
40 days after planting	66.8	63.5

Results show that during the second crop 1959-60 post planting applications of fused Ca-Mg phosphate increased grains yield significantly over applications. Split application $\frac{1}{2}$ at planting and half 30 days later gave highest response. There was however no difference between different levels of phosphate applications nor was the interaction between level $\times$ time of applications was significant.

(c) A small field trial was conducted during the main crop season 1960 on the influence of time of applications of superphosphate and fused Ca-Mg phosphate as grain yield of rice. Variety T. 141 was used in this trial. Data on grain yield are summarised in Table below:

TABLE LIII

Influence of time of application of Super phosphate and fused Ca-Mg phosphate on grain yield of Rice

Control yield 4400

(Mean yield Kgms/Ha)

Time of application	Yield Kg/Ha	
	Super-phosphate	Fused Ca-Mg. phosphate
At planting	4420	4275
20 days after planting	4692	4163
40 days after planting	4407	4368
$\frac{1}{2}$ at planting $\frac{1}{2}$ 30 days after planting	4344	4537

Under field conditions, none of the treatments were found to be very superior to the no manure plots.

I. Varietal susceptibility investigations :

(a) Gall fly : *Pachytiplosis oryzae* (W. M.) Mani.—(i) One hundred and twenty six varieties of 100-120 days duration were studied during the Sarad season in 1958 at the peak period of gall fly incidence from the collection of World Genetic Stocks and were classified on the degree of susceptibility. The incidence ranged from nil in 29 varieties to 22.64% in W. 651. Varieties which showed nil infestation had flowered before the peak period and had escaped the incidence by gall fly.

(ii) Thirty-nine varieties, including 7 green varieties and 32 pigmented varieties were studied in 1958 in a randomized block in four replications for their reactions to gall fly. The range of incidence in the different group of varieties was as under:—

Green non-scented	4.23% to 20.59%
Pigmented in leaf sheath only—	
Light purple	5.18% to 17.24%
Bright purple	5.65 % to 19.03%
Pigmented in leaf sheath & leaf blade	5.56% to 19.06%

Though there seemed to be no significant difference in the range of incidence among the different groups, the incidence was found to be less among the varieties with low tillering ability. It may be pointed out that the variety Maskaty 1315 showed low incidence though it is a multi-tillering variety.

(b) Stem borers : *Schoenobius incertulas* Walk., *Scirpophaga innotata* Walk., *Chilotranea (Proceras) polychrysa* Meyer., *Sesamia inferens* Walk.—Thirty-two rice varieties were tested in a field trial for their reactions to stem borers, during the second crop seasons in the years 1958-59 and 1959-60, under both sprayed and unsprayed conditions. The varieties were grown under normal fertility level (20 lb. N/A) and the sprayed series were given two sets of two sprayings each with Shell Endrex-0.04% to synchronise with the emergence of broods of stem borers. Borer incidence was estimated at two stages; at the early growth phase and at the heading phase of the crop, by drawing random area samples.

Infestation by stem borers at the early growth phase was considerably checked in the sprayed series of varieties; but at the heading phase it was not reduced to the same extent because there was a wide difference in the dates of flowering of the varieties, and since sprayings were suspended at flowering time, the late flowering varieties were affected by the second brood of the stem borers. The varieties under sprayed condition produced more ear bearing tillers and consequently resulted in higher yields. Varieties Ac. 1368, CH. 41, A. S. D. 2, C. B. I and Tepa. II were found to be susceptible both at the early growth phase and at the heading phase, while the varieties TKM. 6 and SLO. 12 showed low incidence at both the phases. Varieties CH. 42 and *Benibhog* showed severe infestation at the heading phase only. In general, the varieties which suffered from severe infestation in the growth phase were of a low tillering habit.

(c) Hispa: *Hispa armigera* Oliv. (*aenescens* Baly).—Preliminary observations on the prevalence on hispa were taken on twenty rice varieties grown in four replications at the Saline Rice Research Substation, Port Canning, West Bengal, during the year 1960, with a view to assessing their relative susceptibility. The varieties were classified on the number of beetles collected in three sweeps, as under:—

TABLE LIV
Varietal reactions to rice hispa

Low (3.0 to 6.0)	Moderate (6.1 to 15.0)	High (15.1 and above)
MQ. 1	<i>Marichsail, Nizersail, Kumarg-re</i> . . .	<i>Sitasail</i>
MTU. 15	<i>Patnai 23, T. 23, Badshahbhog</i> . . .	SLO. 13
<i>Doddakhare</i>	C. 100-22, MTU. 1, C. 100-34 . . .	<i>Rupsail local</i>
SR. 26 B	<i>Budamolagolukulu, Ac. 174, Kanakchur Ashpata.</i>	

These observations need to be confirmed.

II. Insect resistance in rice:

(a) *Resistance to gall fly*.—(i) Five hybrid progenies of crosses between purple pigmented and green non-scented rices in the F_2 generation were analysed for their relative susceptibility to gall fly and for the occurrence and the intensity of pigmentation in different parts of plants, in the year 1958. The results showed that pigmentation in leaf sheath and leaf blade alone influence the degree of susceptibility. The experiment needs to be confirmed.

(ii) Preliminary observations on gall fly incidence were taken in diploid and auto-tetraploid strains of four varieties, *Seta*, SR.26 B, *Indrasail* and GEB. 24. The data indicated that, in general, gall fly incidence was higher in the diploids than in the auto-tetraploids. This investigation needs to be confirmed.

(b) *Resistance to stem borers*.—In order to determine the mechanism for the resistance or otherwise of rice varieties to borers, the prevalence of borer moths and the number of egg-masses were studied by counts in fields for six days after planting in the varieties grown during *Dalua* for varietal susceptibility trial in the year 1959-60. High population of moths (12 to 21) was found in the varieties CH. 47, TKM.3, *Benibhog*, ASD. 2, DI. 4 and HR. 67. The number of moths was low (1 to 6 only) in the varieties Ac. 1368, ADT. 4, CH. 42, *Patnai 6*, HR. 19, CO. 13, *Tepa. I, Tepa. II.* and N. 136. In the rest of the varieties the number of moths present was moderate (7-12). Tiller counts taken in all the varieties at 55 days age indicated that varieties which showed high moth population had an average of 8.1 tillers per plant, while those which showed low moth population had 1.4 tillers per plant. It is, therefore, evident that the varieties with more number of tillers and more leaf area had more number of moths.

In general, varieties which showed high moth population had more number of egg-masses. But, the following varieties which had moderate moth population also showed more number of egg-masses : CH. 41, TKM. 4, CH. 4, CH. 14 and CB. I. This preference for oviposition may be due to the differences in the morphology of the leaf which needs to be studied.

Studies on anatomical characters of stems of different varieties and their relation to the degree of borer incidence, confirmed the previous year's findings, that the strains less susceptible at the heading phase were characterised by thick bands of lignified sclerenchymatous tissue in their stems, while this tissue was poorly developed in the highly susceptible varieties. In the less susceptible varieties, the number of layers of sclerenchyma was 4 to 6 and the pith was narrow inside the stem.

II. Incidence of rice pests in relation to agronomic practices :

With the object of determining the incidence of pests in relation to the age of the crop or the time of planting, 30 days old seedlings of two varieties : CH. 45 and DI. 4 were planted at fortnightly intervals commencing from about the third week of July till the middle of February during the years 1958-59, 1959-60 and 1960-61. Incidence of gall fly and stem borers was estimated by drawing random area samples at 60 and 90 days age of crop and at harvest.

(a) *Gall fly*.—Gall fly incidence commenced in all the years in the crop, planted during the last week of July and examined in August. Crops examined during September in all the years showed the maximum infestation. The peak period for gall fly incidence was found to be during the last week of October in 1958, from the middle of September to the middle of October in 1959 and during the month of October in the year 1960. Infestation in both the varieties : CH. 45 and DI. 4 was significant in the different plantings, the incidence being higher in the variety CH. 45. Irrespective of the date of planting, crops at 90 days age recorded higher incidence than crops at 60 days age in all the three years.

The peak period for natural parasitisation of the immature stages of gall fly was found to be during early October in the year 1958, during November in 1959 and during the last week of October in the year 1960. It may be pointed out that, where as, in the years 1958 and 1959, natural parasitisation reached its peak before the peak period of gall fly incidence, in the year 1960, the peak period of parasitisation had coincided with the peak period of gall fly incidence.

(b) *Stem borers*.—Studies on stem borer infestation have indicated that there was no appreciable damage by stem borers to the *Kharif* crops. Late plantings, viz., those done after September in the year 1958 and after October in the successive two years showed significant incidence at 90 days age and at harvest. Crops planted in December 1958, those planted during the period from the middle of December 1959 till the middle of January 1960 and those planted in October 1960 recorded the highest percentage of borer-attacked plants at 90 days age. Infestation at the heading stage was highest in the crops planted in the middle of December during 1958, early December during 1959 and 1960. In general, the crops transplanted during the middle of January, were subjected to severe infestation by stem borers at both the early growth phase and at the heading phase.

IV. Epidemiology of rice pests :

Investigations on the influence of macro and micro-climatic factors on the prevalence and abundance of rice pests have been in progress with a view to forecasting and taking timely measures for control.

(a) *Gall fly*.—Catches of gall flies at light traps showed their prevalence from the middle of August in the years 1958 and 1960, and from the middle of July in 1959. The population was steadily on the increase till the peak period after which there was a decline. The peak period for the prevalence of gall fly was found to be during the last week of October in 1958. In 1959, the population steadily increased till the second fortnight of September with a decline during October. Maximum number of flies was collected on 23-10-1960 which indicated the peak period for the prevalence.

Phenological studies on the activities of gall flies indicated that maximum number of gall flies was attracted to light traps from 10 P. M. to 2 A. M. The number of male flies was more after 12 o' Clock in the night.

(b) *Stem borers*.—Catches of moths at light traps revealed the prevalence of stem borers from September 1958 till May 1959. Two distinct peaks of population of moths were observed one during early November, 1958 and the other during the last week of February, 1959. The second brood was found to extend over a long period, apparently due to overlapping of generations.

In the year 1959 stray cases of *Schoenobius* moths appeared on 23-8-59 and continued till October. From the last week of October till the third week of December there was an emergence of a brood. A second brood emerged from the 3rd week of January 1960 till the first week of March 1960.

During the *Kharif* season 1960, borer moths first appeared on 29-7-60 and the population reached a peak on 14-11-60, which indicated that a brood had emerged. There was a decline after the peak emergence. A puddled and newly planted plot attracted a huge population of *Schoenobius* moths on the succeeding day after planting, while the standing crop which was dibble sown near-by had no population. Micro-climatic observations in the two plots showed that the temperature and relative humidity prevailing at the base of the culms in a transplanted crop were 26.95 °C and 65.50 per cent respectively, which seemed to be favourable for oviposition by stem borer moths, while in the dibbled crop of the same age, the temperature and relative humidity were 26.55° C and 61.76 per cent respectively.

(c) *Hispa*: *Hispa* (*aenescens* Baly) *armigera*, Oliv.—Stray beetles of hispa were first noticed on 28-8-60. The population assumed a sporadic pest form this year after its last appearance during September in the year 1949. The infestation was noticed in ill-drained plots. During the period of their prevalence from 28-8-60 till 3-10-60, the climate was dry and humid due to intermittent drizzles followed by spells of dry weather. The temperature ranged from 23.8 °C to 33.4 °C and the range of relative humidity was from 83 to 97 per cent. The total rainfall during the period was (21.61cm.) 8.51".

V. Efficiency of different methods of application of insecticides in controlling gall fly:

Rice crop is subject to gall fly infestation from August till November, during which period there are over 5 to 8 generations, depending on the weather conditions. As the entire growth phase of *sarad* crop is subject to infestation, an investigation was laid out to determine the stage of the crop to be sprayed and the minimum number of sprayings required for effective control. The results of these investigations are given in Table LV.

Symbo	1958				1959				1960			
	Date of final observation	25-10-58		Yield	Date of final observation	4-10-59		Yield	Date of final observation	21-10-60		Yield
		Gall fly incidence	% attack			Gall fly incidence	% attack			Gall fly incidence	% attack	
	Treatments			Kg/Ha	Treatment			Kg/Ha	Treatment			Kg/Ha
T ₁	Five sprayings at weekly intervals from 35-63 days after planting (30th August to 27th September).	0.45	..	3240.87	Four sprayings at intervals of 10 days from 47-77 days after planting (8th September to 25th October).	31.38	12.25	2802.69	Four sprayings at weekly intervals from 35-63 days after planting (10th September to 1st October).	36.41	31.25	1674.33
				5.50				19.31				13.93
T ₂	Five sprayings at weekly intervals from 56 to 84 days after planting (20th September to 18th October).	1.25	..	3332.70	Four sprayings at intervals of 10 days from 57-87 days after planting (18th September to 25th October).	..	..	2688.09	Four sprayings at weekly intervals from 49-70 days after planting (24th September to 15th October).	51.95	1.90	1628.15
				8.99				14.43				10.79
T ₃	Thirteen sprayings at weekly intervals from 7-84 days after planting (2nd August to 18th October).	0.15	..	3606.12	Nine sprayings at intervals of 10 days from 7-97 days after planting (6th August to 25th October).	28.19	15.42	2992.18	Ten sprayings at weekly intervals from 7-70 days after planting (13th August to 15th October).	36.25	31.55	2013.61
				17.40				27.31				37.02

The variety GEB. 24 was transplanted in a randomized block in four replications, each comprising six treatments. The treatments included in the year 1958 were check and spraying Shell—Endrex. 0.04% at weekly intervals at different phases of crop growth: *viz.*, 7 to 35 days, 21 to 49 days, 35 to 63 days, 56 to 84 days and 7 to 84 days after planting. Infestation in the different treatments was estimated at the commencement and at the end of the spray rounds in each treatment. The results indicated that spraying the crop for five times at weekly intervals commencing from 35 to 63 days after planting was as effective as spraying from 7 to 84 days in reducing gall fly incidence. The variety GEB. 24 reached its maximum tillering phase during the middle of September, which was also the peak period for gall fly incidence.

With a view to reduce the number of sprayings further, the experiment was repeated in the year 1959 with six treatments in the variety GEB. 24: *viz.*, Check, spraying the crop at intervals of 10 days four times with Parathion—0.08% (Folidol-E. 605 E. C-46.5%) commencing from the 7th day, 27th day, 47th day, 67th day after planting and spraying from the 7th to 87th day after planting. The result confirmed the previous year's findings that spraying during the vulnerable stages of crop was as effective as spraying the crop during the entire growth phase. Spraying from 47 to 77 days after planting resulted in a decrease in incidence by 12.25% and increase in yield by 19.31% whereas spraying from 7-87 days after planting resulted in a decrease in incidence by 15.42% and increase in yield by 27.31% over check.

This experiment was repeated in the year 1960 with a view to reduce the sprayings and the interval between successive sprayings and yet effectively control gall fly. In general, gall fly incidence induces tillering and the newly formed tillers are invariably affected. It was, therefore, designed to protect the potential ear-bearing tillers by spraying. The treatments were the same as were laid out in the year 1958 but the number of weekly sprayings was limited to four and the insecticide used was Parathion—0.08%. The treatments, *viz.*, Check, spraying the crop at weekly intervals commencing from the 7th day, 21st day, 35th day, 49th day and from 7th day till the 70th day after planting. Sampling technique employed during the 1959 experiment was adopted. But in the observations on incidence the tillers from each sample were separated into "big" and "small" based on their relative position on the plant and the "small" tillers which were not potential ear-bearing tillers were discarded for purposes of estimation of gall fly incidence.

As in the previous years, spraying for four times at the vulnerable phase of crop *i.e.*, from 35 to 63 days after planting has resulted in 31.25% decrease in incidence and 13.95% increase in yield, while spraying the crop for ten times, *i.e.*, from 7 to 70 days after planting resulted in 31.55% reduction in incidence and 37.02% increase in yield over unsprayed or check. There was a corresponding increase in yields in the other sprayed treatments and in the number of ear-bearing tillers at harvest. The increase in yields in the sprayed treatments could be attributed to the effect of spraying during the active tillering phase and thus protecting all the tillers of first and second order which are high yielding.

VI. Incidence of stem borers in relation to spacing:

The effect of spacing adopted in transplanting seedlings on the prevalence and incidence of stem borers was investigated in an experiment with the variety PTB. 10 in the year 1959-60. Four treatments: 3" × 6" (T₁),

6" × 6" (T₂), 6" × 12" (T₃), 12" × 12" (T₄) were introduced in a randomized block with four replications. The prevalence of moths was estimated by actual counts of moths in the field. Stem borer incidence was estimated at both the early vegetative growth phase and at harvest, and for this purpose, systematically placed plants to represent ten per cent of the total plant population were uprooted and the degree of infestation was estimated. The data is given in Table LVI.

TABLE LVI
Incidence of Stem borers in relation to spacing

Treatments	Number of moths (Mean) per sub-plot	Growth phase		Heading phase		Yield of grain per plant (mean) Gms.
		No. of tillers per plant (mean)	% attack	No. of earheads per plant (mean)	% attack	
T ₁ 3"—6" . . .	3.50	4.71	28.16	2.13	14.02	2.36
T ₂ 6"—6" . . .	1.50	7.26	26.37	4.25	10.50	5.00
T ₃ 6"—12" . . .	2.15	7.27	23.39	3.21	10.46	4.09
T ₄ 12"—12" . . .	0.65	9.89	35.26	7.83	10.55	8.13
C.D. 05.		1.41	5.47	0.85	6.11	2.68

From the above data it may be seen that the number of moths was significantly high in T₁ followed by treatments T₃ and T₂. The number of moths was least in T₄ where the number of plants and leaf area were less. There was no difference in the mean number of tillers per plant in T₂ and T₃ but between T₁ and T₄ this difference was highly significant. Infestation at the early growth phase did not show significant difference in the percentage of borer attacked tillers between T₁ and T₂. There was significant difference between T₃ and T₄, the infestation being least in T₃ and highest in T₄. Between treatments T₂ and T₃ there was no significant difference. The mean number of ear heads per plant was significantly different in the four treatments. There was no significant difference in the incidence at the heading phase of the crop, though the percentage of attacked tillers was slightly higher (14.02) in T₁ than in the other treatments. Comparison of the mean yields per plant revealed significantly high yields in T₄ and T₂. The following indications were noted:—(1) Wide spacing was more conducive for borer infestation at early growth phase. (2) There was high incidence at the growth phase in the crop planted at 12" × 12", the infestation at the heading phase was not significantly different from that in the crop planted at 6" × 6" or 6" × 12" spacing. (3) Though the yield of grain per plant was significantly high in the crops planted at 12" × 12" spacing, the estimated yield per acre were of the order T₂ (6" × 6"), T₁ (3" × 6"), T₃ (6" × 12") and T₄ (12" × 12").

VII. Intensity of stem borers within a field:

In a plot measuring 10.0 M $\times$ 38.0 M, variety Ptb. 10 was transplanted in singles at a uniform spacing of 0.25 M $\times$ 0.25 M. Incidence of stem borers was estimated by drawing random area samples at both the early growth phase and at the heading phase. The plot was stratified into 4 concentric rings each of 2 metres width and a central zone of 3 metres width. The zones were numbered serially in the centripetal manner. The mean number of egg-masses was highest in the peripheral zone. The percentage of borer attacked tillers was highest in zone III and lowest in the peripheral zone. The percentage of borer attacked tillers was highest in the peripheral zone and lowest in zone IV.

Mycology

I. Study and estimation of resistance to disease in field of the collection of types under genetic stock:

In the seed-beds raised during 1958, there was only a negligible incidence of diseases. Blast (*Piricularia oryzae* Cav.) as well as Helminthosporiose (*Helminthosporium Oryzae* Breda de Haan=*Cochliobolus miyabeanus* (Ito et Kurib). Dresch. Ex Dastur) were, however, noticed in 1959 in the crop at the seedlings stage; 171 types were found susceptible to blast and 32 to helminthosporiose in the collection of genetic stocks. In the World Collection of 711 types maintained at the Institute, 12 were found susceptible to blast. Again in 1960, the seed-beds had a very low disease incidence.

Observations at the tillering and flowering stages were confined to the early varieties of the genetic stocks (maturing within 130 days) numbering about 780 in the Institute collection and 220 in the World catalogue types. Only five were found susceptible to blast and six to helminthosporiose at these stages, in 1958; in 1959 blast incidence was more, with 75 varieties showing susceptible reaction to blast but only two were found susceptible to helminthosporiose.

In 1960, there was a particularly severe attack of bunt *Neovossia horrida* (Tak.) Pad et A. Khan) and false smut (*Ustilaginoidea Virens* Cke). Bunt was observed to be particularly heavy in the medium duration varieties (130-150 days); the incidence was low in varieties below 135 days duration, and was totally absent in the varieties of about 150 days duration. Observations on the incidence of bunt were recorded on 434 varieties of the Genetic Stock of durations 135, 140, 145 and 150 days. The infection was graded as light, medium and severe basing on the number of grains affected in an ear-head (i.e., 1-5 grains in an ear-head as light; 6-10 grains in an ear-head as Medium; and about 10 grains in an ear-head as severe. It was seen that 600-1000 grains were generally present on an average in a panicle).

Of the 434 varieties observed, 45.39% varieties were infected. Out of the diseased types, 34.01% were of 135 days, 44.16% were of 140 days and 1.83% were of 145 days duration.

The relation between severity of incidence of infection and the duration of varieties suggests that the seasonal conditions prevailing at flower opening of the varieties have some influence on infection (other characters were perhaps responsible for the variability in infection within the group of varieties

of same duration). The intensity of bunt infection in the different varieties observed in is presented in Table below :

TABLE LVII
Intensity of bunt infection on different varieties of rice

	Duration of varieties (in days)			
	135	140	145	150
Total No. of varieties	77	117	182	59
No. of diseased plants	67	87	43	..
Percentage of diseased plants	87.01%	84.36%	23.63%	..
Intensity of infected plants under different varieties.				
Light	59.70%	83.90%	88.37%	..
Medium	25.37%	8.05%	9.30%	..
Severe	14.93%	8.05%	2.33%	..

II. *Helminthosporium disease—Breeding for—disease resistance :*

1. *Isolation of resistant varieties.*—(a) *Improved types.*—During 1947-1954, the collection of 538 improved strains of cultivated rice were tested for their resistance to helminthosporiose, using a standard technique evolved for the purpose at the Institute. Six varieties were finally selected as resistant (CH. 13, CH. 45, T. 141 and BAM. 10, T. 498-2A, and Co. 20). The seeds of five of the varieties (as Co. 20 was found very susceptible to blast, it was not distributed) were distributed to all the States in India during 1955-56-57 and were tested under local conditions in as many research centres as possible. The first four varieties were found resistant to moderately resistant in most of the centres and T. 498-2A was found to be moderately resistant to moderately susceptible.

(b) *Short duration types from genetic stock.*—A second set of 497 varieties from the genetic stock, all of early duration (110 days) were taken up for tests during 1955. During the course of tests carried out during the period 1955-59, twelve varieties were selected as relatively resistant to the disease. These twelve varieties were subjected to final rigorous confirmatory tests during the current year and the following eight varieties have been finally selected for distribution to the states for a test of their performance under local conditions as was done during 1954-57.

Varities:

A.C. Nos. 1351, 1382, 2041, 2045, 2052, 2465, 2559, 2966.

(c) *Reaction of Kerala varieties.*—Eight varieties were received from Kerala State for testing their reaction to the disease. They were tested during the

year under artificial infection in the seedling stage and were found to react as follows:—

TABLE LVIII

Reaction of varieties received from Kerala against Helminthosporiose

Varieties														Reaction
PTB.4	.	.	.	.	.	.	.	.	.	.	.	.	.	MR
PTB.12	.	.	.	.	.	.	.	.	.	.	.	.	.	R
PTB.15	.	.	.	.	.	.	.	.	.	.	.	.	.	R
PTB.18	.	.	.	.	.	.	.	.	.	.	.	.	.	R
PTB.20	.	.	.	.	.	.	.	.	.	.	.	.	.	R
PTB.21	.	.	.	.	.	.	.	.	.	.	.	.	.	R
PTB.27	.	.	.	.	.	.	.	.	.	.	.	.	.	R
PTB.33	.	.	.	.	.	.	.	.	.	.	.	.	.	MR

R—Resistant.

MR—Moderately Resistant.

They will be further tested to confirm the above results.

2. *Breeding resistant varieties by hybridization.*—As reported under section of Botany F_4 to F_6 progenies of crosses between BAM 10 (resistant to helminthosporiose but susceptible to blast) and Co. 25 (Susceptible to helminthosporiose but resistant to blast) were studied during the years under review. Thirty field selections were made on the basis of number of fertile tillers and resistance to both the diseases, in the year 1960 from F_6 progenies of crosses.

3. *Studies on the nature of disease resistance of rice varieties.*—*Effect of addition of nutrients to leached soil on the incidence of the disease.*—The object of the study was to see whether severe incidence of helminthosporium usually noticed towards flowering season in leached soil of heavy monsoon areas could be checked by the supply of suitable nutrients before flowering of the varieties.

The experiment was started in the year 1959 and repeated during the second crop season of 1959-60. During the present year the experiment was carried out using two early duration varieties viz., CH. 13 and Benibhog and two late duration varieties viz., BAM. 10 and Latisail, Benibhog and Latisail being susceptible and the other two resistant. During the second crop season early duration varieties were used.

The plants were grown in pots with well sieved field soil to which a basic dose of N.P.K. were added. The soils in the pots were thoroughly leached with water at the boot-leaf stages of the respective varieties and the different fertilizer combinations as mentioned in the Table LIX, were added in the respective treatments. The plants were artificially infected with spore suspension

of *H. oryzae* in water, or with mycelial and spore dust a week after the leaching. Observations on disease incidence was taken 10-15 days after inoculation.

TABLE LIX

Table showing the different treatments in the experiment on addition of nutrients to leached soil. (1960-Main crop)

Treatments
(i) T ₁ —Control—(No manuring, no leaching).
(ii) T ₂ —(Basal manuring—no leaching).
(iii) T ₃ —(Basal manuring—leaching—no re-manuring).
(iv) T ₄ —(Basal manuring—leaching—only Ammonium sulphate applied).
(v) T ₅ —(Basal manuring—leaching—only Superphosphate applied).
(vi) T ₆ —(Basal manuring—leaching—only Potash applied).
(vii) T ₇ —(Basal manuring—leaching—NPK applied).

Fertilizers applied were as follows:

1. *Basal manuring*.—Combination of N. P. & K. (5 gram ammonium sulphate, 3.2 grams superphosphate, 1 gram of K per pot containing 20 kgm. field soil).

2. *Application of fertilizers after leaching*.—Half of the above dosage of either N or P or K or their combinations were applied after leaching.

It was observed in the year 1959 that infection of helminthosporiose was higher in the plants growing in leached soil in comparison with those growing in unleached soil; further, the plants which received Ammonium sulphate after leaching had higher infection than those growing in leached soil without such an addition. On the other hand, the plants which had received N & P, and P & K, during 1959, after leaching had lower infection than those which had received N alone after leaching.

The experiment was repeated with the early duration varieties *Benibhog* (susceptible) and CH. 13 (resistant) in the second crop season (January to April, 1960) and the above results were confirmed.

The effect of leaching was not reflected on the disease incidence during the main crop season of 1960. Addition of nutrients N, P or K, alone after leaching was associated generally with slight reduction in infection. Addition of N, P, K in combination had the opposite effect.

III. Blast disease : A—Breeding for disease resistance :

(i) *Isolation of resistant varieties.*

(a) *Improved types*.—As mentioned under '*helminthosporium disease*' earlier, the stock of 538 improved strains were tested during 1947-1954, and 16 types were selected as resistant to moderately resistant; they were also distributed to rice research stations in India where they were tested for three seasons 1955-56-57 under local conditions. The selected varieties reacted as at Cuttack in most of the Stations, but in the high elevation stations at Mahabaleswar, Kanke, Kalimpong and at Agartala none were found uniformly resistant except S.67 & Ptb. 10.

(b) *Short duration types*.—The collection of 497 short duration types 110 days available at Central Rice Research Institute were taken up for testing in 1955. During 1955-60, twenty-four varieties mentioned below have been selected as relatively resistant. The seeds of these varieties will be distributed to the states for a test of their performance under local conditions during 1961.

Accession numbers:

27	550	1337	1730	2250
28	1182	1387	1771	2489
71	1267	1423	1773	2565
75	1298	1443	1966	2597
533	1315	1613	2082	

(c) *Short duration type (second series)*.—During the year 1960, a third lot of varieties from the genetic stocks were taken up for testing their resistance to blast disease; they consisted of 340 varieties of short duration 111-125 days available in the genetic stocks. In the course of preliminary study under field condition, nine varieties were found infected in the field in the post transplanting stage (leaf infection). There was no seed bed or neck infection observed in these varieties during the year. The season was apparently very unfavourable for blast infection.

These types were also subjected to artificial infection in the seedling stage.

Even under artificial infection only 16 types developed typical susceptible reaction. The remaining types will be subjected to artificial infection tests and will also be kept under observation in the field during 1961 and 62 for selection of resistant varieties.

(d) *Short duration varieties in World Genetic Stock Collection of F.A.O.*—A collection of 711 varieties registered with the F.A.O., is also being maintained at Central Rice Research Institute. There are 220 varieties maturing in 110-135 days in the F.A.O. collection. They have also been taken up for isolation of resistant varieties since 1957. As a result of observations carried out in the field and artificial infection studies in the seedling stages, 130 varieties had been eliminated as susceptible during 1957-59. During the current year 90 remaining varieties were tested under artificial infection in the seedling stage. Eighteen varieties were found susceptible and seventy-two have been carried forward for further tests.

(e) *International Co-operative trials on breeding for blast resistance*.—In pursuance of the recommendations of the Working Party on Rice Breeding of the F.A.O. held in Malaya in 1955, seeds of 53 varieties resistant to blast were collected from 9 rice growing countries distributed to testing centres in U.S.A., Japan, Taiwan, Siam, Philippines and India (Cuttack). The results from India, Japan, the U.S.A., and the Philippines, which were available for comparison, are presented below.

Resistant varieties.—Out of 53 varieties received, none were uniformly resistant in all the countries.

Japanese varieties.—According to the system adopted in the above classification none of the 9 varieties sent from Japan as resistant proved to be resistant in the country of origin in the tests carried out. However, they were mostly moderately susceptible in the Philippines and moderately resistant in the U.S.A. In India, Norin. 17 and Norin. 22 proved to be highly resistant. The others were found to be susceptible.

Egyptian varieties.—All the three varieties sent from Egypt as resistant proved to be susceptible in India, while Giza. 14 was susceptible in Japan and moderately resistant in the USA.

Indian Varieties.—Amongst the 8 varieties submitted as resistant from India, the most resistant was Co. 4, but unfortunately it was not tested in any country outside India. S. 67 which is another resistant variety proved to be resistant in the USA, India and also Japan in all the tests except one. B.J. 1 was similarly resistant in USA and India, but not in Japan.

Indonesian varieties.—Out of the 8 varieties sent from Indonesia as resistant, *Bengawan* was moderately resistant in Japan, resistant in India and Philippines and moderately susceptible in USA. The other varieties were all susceptible in India but were mostly moderately resistant to moderately susceptible in Japan, Philippines and USA.

Amongst the 2 varieties submitted as resistant from the Philippines, *Raminad Str.* 3 was resistant in India, but susceptible in Japan.

Taiwan varieties.—All the 3 varieties submitted as resistant were susceptible in Japan, while two were resistant in India.

USA varieties.—The six varieties from the USA submitted as resistant were found to be susceptible in Japan and the Philippines; 3 were also susceptible in the USA. In India, their reaction varied from resistance to moderate susceptibility.

Burmese varieties.—All the 18 Burmese varieties submitted as resistant proved to be susceptible.

Susceptible Group.—Almost all the varieties received as susceptible from the various countries proved susceptible in these tests, the notable exceptions being *Norin. 1*, which proved to be resistant in Philippines, the USA and India, and *Mas* which appeared to be moderately resistant in Japan.

(ii) *Breeding resistant varieties by hybridization.*

As reported earlier in the section of Botany cultures from F_4 to F_{11} progenies of crosses between Co. 25, a long duration variety resistant to blast and Co. 13, a short duration variety, highly susceptible to blast, were studied during the three years. Three hundred and fifty eight field selections were made on the basis of their resistance, earliness and number of fertile tillers in 1960 and 1961 have been carried forward in F_7 - F_{14} .

Nine of the cultures from different generations (F_{11} , F_{12} and F_{13}) were raised in bulks. Out of these two cultures in F_{12} and F_{13} yielded 2600 and 2900 lb./acre. T. 141, the high yielding standard which matured in 10 days later than the above two cultures recorded an yield of only 2400 lb./acre in

this experiment. Two of the best cultures were grown in the fields of 10 or 20 or 40 cents during 1958, 1959, 1960 in the first and second crop seasons. On an average 2600-3000 kg./ha of grain were obtained both in the first and second crop season.

The seeds of these two promising blast resistant cultures will be distributed to all the Rice Research stations of the country for trial under the local conditions. They mature in 135 days, are fairly non-lodging and are the highest yielders in the farm in the 130-140 duration group. They respond very well to high fertilization levels (60 lbs. of N/acre). They have been tested in the second crop season also (December-April) and have been found to be blast resistant and high yielders during this season also.

(iii) *Studies on the nature of disease resistance of rice varieties.*

(a) *Incidence of infection at germination.*—In order to find out whether infection tests of rice varieties during germination (within 7 days after sowing) could be used as an index of their reaction to the disease, the following experiment was carried out.

(1) Seedlings of resistant and susceptible varieties of rice were grown in flasks and inoculated with the spore suspension of *Piricularia oryzae* (blast fungus).

It was observed that tests based on the reaction of varieties to blast during germination is not probably a good index of their reaction to the disease at all stages. This study is being continued.

(2) In another test, the seeds of the varieties were germinated in petridishes with about 10-12 days old fungus culture. There was no difference in the germination of resistant and susceptible varieties.

(b) *Penetration of pathogen in resistant and susceptible varieties and development of infection.*—A preliminary study was carried out to assess the nature of mechanical resistance, if any, offered by rice to penetration by blast fungus. A simple technique was standardised for undertaking the study. It was found that conidia of *Piricularia oryzae* germinated better in 5% dextrose solution than in distilled water. Further, it was observed that the optimum temperature for germination of the conidia was 25°C. Fresh leaf-bits from the middle portion of the laminae of plants of Co. 13 (variety susceptible to blast) were floated in a 5% dextrose solution, containing a suspension of freshly harvested conidia and were incubated at 25°C.

It was observed that the conidia germinated readily and formed appressoria in 17 hours after the inoculation. The germ tube grew out in a zig-zag manner and formed typical appressoria, hemispherical in shape and brown in colour.

The appressoria were generally found in the epidermis mostly among the papillae and occasionally around the base of the epidermal hairs, whereby it is inferred that cuticular penetration is usual and penetration at the base of the epidermal hairs is also likely.

B.—*Antibiotic action of actinomycetes on rice pathogens:*

An organism (actinomycetes) was isolated in the laboratory and tested for its antagonistic activity on rice pathogens (*Piricularia Oryzae* and *Helminthosporium oryzae*).

(i) *Laboratory studies*.—The extract of the broth obtained from the strain grown at 30°C. showed a high degree of antagonism to *Helminthosporium oryzae* causing helminthosporiose, and *Piricularia oryzae* causing blast disease of rice. Both the extract and the broth containing the living organism when added in small quantities (2 c.c.) to the medium (20 c.c.) completely inhibited the growth of both the above mentioned fungi.

The actinomycete was cultivated in glucose broth medium and maintained at room temperature during the day (nearly 28°C) and at 30°C during night. It was kept aerated by shaking for about 6 hours a day. At the end of the five days, the mycelium was filtered. The growth obtained in three flasks with 50 m.l. of medium each yielded a good crop of mycelium. The mycelium was extracted with 10 m.l. of water, centrifuged with a hand centrifuge for half an hour, and a clear pale yellow liquid was obtained by decantation; the residual mycelium was again extracted with 10 m.l. of ethanol. The ethanol extract was much paler than the water extract. Dilutions of 1/10 to 1/1,00,000 of the extracts, completely inhibited the germination of the spores of *P. oryzae*.

(ii) *Field studies*.—Recently it was reported that antibiotics were being used in Japan for the control of blast disease in the field. Two antibiotics, Antimycin A and Blastimycin were obtained from Japan. The antibiotic broth obtained from the *Actinomycete*, isolated at Cuttack, was also tried along with the above two Japanese antibiotics.

Preliminary trials with the Japanese and Indian antibiotics showed that there were no toxic symptoms on rice sprayed with the antibiotics at the 1/10,000 dilution. Large scale field trials were carried out with the antibiotics at the above dilutions. In the field trials, a fungicide (Mercurised copper oxychloride) was also included (at 0.6 lb./acre) to test the efficacy of the antibiotics as compared to the fungicide.

There were five treatments viz., 3 antibiotic, one fungicide and control. The experiment was laid out as a simple randomised block with 8 replications, each unit plot being 29' × 9.7'.

Co. 13, a short duration susceptible variety was grown. The seed bed was sown on 6/7/60 and 36 days' old seedlings were transplanted on 16-8-60. Green manure to give 20 lb./N per acre was puddled in before transplanting. Ammonium sulphate at the rate of 40 lb./N per acre was supplied a month after transplanting.

As there was practically no blast infection except is some stray plants in the leaf at the post transplanted stage, only two spray applications were given, one before and another after flowering. The rate of application was 20 gallons per acre applied with low-volume nozzles.

There was no neck infection even in the unsprayed control plants at the time of harvest. The yield data obtained under the different treatments are given below in Table LX.

TABLE LX

Yield (lb./acre) obtained with antibiotics and mercurised copper oxy-chloride sprays on Co. 13

Antimycin 'A'	Blastimycin	CRRI Antibiotic	Mercurised copper oxy- chloride	Control	C.D. at 5%
1411	1520	1477	1469	1322	201

It might be seen that all the treatments were associated with increased yield but the differences were not significant. As there was no severe blast the relative efficacy of the treatments in controlling the disease could not be determined.

C—Control of blast by fungicide :

1. *Spraying trials.*

(a) *Effect of organomercurial sprays.*—The mercurial fungicides Mema, Aretan and Ceresan (wet) and Fernide (Thiram) were used as spray chemicals to test their efficacy to control blast for three years in succession since 1957. The mercurial fungicides were standardised at the rate of 0.195 lbs. of metallic mercury per acre and Fernide (Thiram) at the rate of 5 lbs./acre. Unsprayed plots were kept as control. The experiment was planted with Co. 13 a short duration type susceptible to blast. The layout was a randomised block with 8 replications and the area of the unit plot was 29 ft. $\times$ 9.75 ft. Twenty five days' old seedlings were planted on 12-8-1958 and ammonium sulphate at the rate of 40 lb. N per acre was applied one month after transplanting in addition to the basal dosage of green manure applied @ 20 lb. N/acre. Three sprayings, one before and two after flowering in the year 1958 and two sprayings one before and another after flowering in the year 1959 were given. 100 gallons of spray fluid per acre was used for each spraying.

Observations on neck infection were taken from four random samples of 2.25 ft. $\times$ 2 ft. each per unit plot. The data on percentage of neck infection and yield are presented in the table below:

TABLE LXI

Showing the efficiency of organomercurial fungicides used as spray to control blast disease of rice

	Year	Ceresan (Wet)	Aretan	Mema	Fernide (Thiram)	Control	C.D. at 5% level
Percentage of neck infection.	1958	5.09	4.80	6.68	8.90	13.56	..
	1959	2.7	2.51	2.9	3.9	6.62	
Angular values of figures under neck infection	1958	12.97	12.49	14.82	17.26	21.54	1.95
	1959	9.44	8.89	9.61	11.32	14.77	1.645
Mean yield/acre in lbs. .	1958	691.24	1075.72	840.54	578.76	404.93	122.71
	1959	1625	1727	1804	1623	1585	

It may be seen from the table that the level of neck infection was very low being only 13.56 and 6.62 per cent respectively, in the unsprayed control during the two years mentioned above. All the three spray fungicides were associated with significantly lower percentage of neck infection than control. The difference in the percentage of neck infection was not significant between the plots treated with spray fungicides Aretan, Ceresan (Wet) and Mema.

(b) *Efficacy of low volume spraying with copper fungicide.*—It has been observed that a considerable amount of fungicide could be saved with the use of low volume nozzles in the sprayers. The relative efficiency of low volume spraying and efficiency of normal volume spraying in controlling blast was investigated in the year 1958 by using Coppesan (0.5%) as the spray fungicide. The variety Co. 13 susceptible to blast was used. The crop was planted on 11-8-1958 in plots of 93' × 11.25' arranged in a randomised manner having nine replications. Ammonium sulphate @ 40 lbs. N/acre was added one month after the transplanting in addition to the basal dosage of green manure applied @ 20 lbs. N/acre. The treatment consisted of (1) two sprayings, one before and one after flowering, using ordinary nozzles, spraying at the rate of 100 gallons per acre (normal volume spraying), (2) similar number of sprayings with low volume nozzles at the rate of 20 gallons per acre for each spraying and (3) control (unsprayed). Sprayings were done on 16-9-1958 (before flowering) and 17-10-1958 (after flowering). Observations on neck infection was taken by sampling; twelve samples of 2.5' × 2.0' were examined from each of the unit plots. Yield of plots were recorded. The data are presented in Table LXII below :

TABLE LXII

Showing the effect of low-volume spraying vs. normal volume spraying in controlling blast disease of rice

	Normal volume spraying	Low- volume spraying	Control	C.D. at 5% level
Percentage of neck infection	9.21	15.54	30.79	..
Angular values	17.61	22.83	33.32	5.34
Mean yield per acre in lbs.	1111.94	874.26	621.59	125.56

It may be seen from the table that the unsprayed control developed 30.79 per cent of neck infection. Both the low volume spraying and normal volume spraying significantly reduced the neck infection to 15 and 9 per cent, respectively. The spraying treatments were associated with significantly higher yield over the control, though the yield obtained under normal volume was in this year higher than that obtained under low volume.

(c) *Efficacy of low volume spraying with organo-mercurials—Trial of organo-mercuric compound "Aretan" at low volume rates.*—The results obtained in the spraying trials with copper fungicides carried out during 1954-59 have shown that the cost of application of fungicidal spray could be cut down to a considerable extent by using low volume sprays at 20-25 gallons of spray per acre as against the usual rate of 100 gallons. Field trials carried out during 1956-1960 have shown that Aretan (Organo-mercuric compound) was the most effective fungicide in controlling blast and increasing the yield of rice but the trials were carried out at 100 gallon rate. Therefore, it was considered necessary to carry out further trials with Aretan to compare its efficacy at low volume of 20 gallons with its performance at 100 gallon application.

The two varieties Co. 13, susceptible to blast and T.6522 resistant to blast were used. The crop was transplanted on 12-8-1960. The layout of the field was a split plot with the varieties as the main split. In addition to about 30 lb. N/acre supplied as green manure at puddling, 40 lb. N/acre was given as Ammonium sulphate one month after transplanting.

The spraying treatments were : (i) low volume spray at 20 gallon (ii) normal volume spraying at 100 gallon and (iii) control. Aretan was used at a concentration of 0.195 lb. Hg. per acre under normal volume of 100 gallon; the same solution was applied in the low volume treatment also. Two spray applications were given, once before flowering and the second after flowering. There was practically no neck infection observed at the time of harvesting though stray leaf spots were noticeable on some individual plants at the tillering phase.

The yield obtained with the three treatments were as follows:—

TABLE LXIII

The yield in lb. of T. 6522 (resistant to blast disease) and Co. 13 (susceptible) under low volume (20 gallons) and normal spray (100 gallons) with "Aretan"

Variety/Treatments	Normal volume spraying 100 gallons /acre	Low vo- lume spraying 20 gallons /acre	Control Unspray-	C.D. at 5% between	
				Treatment mean	Treat- ment means within a variety
Co.13 (susceptible)	1651	1639	1489	371	149
T.6522 (resistant)	1768	1710	1731	..	..
Mean	1709	1675	1610	..	..

It might be seen from the table that there was very low response to the spraying treatment in the case of the resistant variety. However in the case of Co. 13, susceptible to blast, both low volume and normal volume applications were associated with higher yields, which were significantly higher than the yield obtained with the control, but there was no difference between the

low volume and normal volume treatments in this respect. The cost of the treatments and the value of return obtained are mentioned in table below:

TABLE LXIV
Economics of low volume spraying of fungicides to control blast disease of rice (Co. 13)

Fungicide	Treatment	No. of Sprays given	Cost of fungicide per acre	Cost of labour	Increased Yield/acre in lbs.	Value of increased yield at Rs. 8 per md. (82 lbs.)	Net Return
			Rs. nP.	Rs. np.		Rs. nP.	Rs. nP.
Coppesan (copper fungicide).	Low volume	2	6.96	2.50	+252.67	+24.64	+15.18
	Normal volume.	2	34.80	2.50	+490.35	+47.84	+10.54
Aretan (Organo-mercurial).	Low volume	2	6.79	2.50	+150.00	+14.63	+5.34
	Normal volume.	2	33.96	2.50	+162.00	+15.80	-20.66

+ = Gain.

- = Loss.

(d) *Studies on injurious effect of copper based fungicides on rice.*—In order to study the reaction of popular varieties sprayed with copperbased fungicides an experiment was conducted in 1959 with 16 varieties of rice of different durations belonging to different blast susceptibility groups. The plants were treated with Coppesan (0.5%), a copper fungicide as follows.

- (1) Two normal volume sprayings @ 100 gallons per acre,
- (2) Two low volume sprayings @ 20 gallons per acre, and
- (3) Control (unsprayed). There was very little incidence of blast disease. The injurious effect of copper was noticed in some of the varieties specially under normal volume spraying. Variety S.R. 26B showed significant depression in yield under normal volume spraying. Even in the absence of severe blast incidence, the yield obtained with low volume spraying was found to be significantly higher than the yield obtained under normal volume spraying and the control (unsprayed).

2. Dusting Trials :

It has been observed that dusting fungicides on the crop as a plant protection measure has got certain advantages over sprayings. Dusts are easy to handle and can be transported quickly to the fields where they are to be applied. The organo-mercurial fungicides, Ceresan, slaked lime and Agrosan were used as dusts in the experiments carried out in the years 1958 and 1959 to note their efficacy in controlling blast. The metallic mercury was standardised to have 0.06 lb. Hg. per acre for each application, their efficacy of the fungicides in checking neck infection was compared with that of Bordeaux mixture (5.5.50) sprayed under normal volume of 100 gallons per acre. There was a control plot which was neither sprayed nor dusted. The variety used was Co. 13 (Susceptible). The layout was a randomised block using four replications and the area of unit plot was 128' × 30'. The fungicides were

applied twice, once before and another after flowering. Observations on the incidence of neck infection were taken from 16 samples of $2.25' \times 2.0'$ from each of the unit plots. The yield data and the percentage of neck infection observed in the different treatments are presented in the Table below.

TABLE LXV

Showing the efficiency of organo-mercurial fungicides used as dust to control blast disease of rice

	Year	Agrosan (dust)	Ceresan (dust)	Bordeaux Mixture (spray)	Control	C D. at 5%
Percentage of neck infection	1958	3.98	3.85	3.25	10.00	
	1959	2.54	2.62	3.16	5.12	
Angular values . .	1958	11.18	10.93	10.04	18.25	5.15
	1959	9.12	9.26	10.07	12.81	1.91
Mean yield/acre in lbs.	1958	783.01	1032.20	867.35	572.40	288.00
	1959	1502	1333*	1598	1646	

* Scorching effect on foliage seen.

It may be seen that, the incidence of neck infection was very low being 10.00 and 5.12 per cent only in the control during the year 1958 and 1959 respectively. The plots treated with fungicides developed 3—4% and 2.54—3.16% neck infection during the years 1958 and 1959 respectively, and which was significantly lower than that in the control, but the differences between the fungicidal treatments were not significant.

The yield was significantly higher in all the fungicidal treatments over the control, but between the treatments the differences were not significant.

3. Loss in yield due to blast :

The trial was carried out in the year 1958 with six varieties, two early (Co. 13 & T.6522), two medium (T.1145 & SM.8) and two late varieties (ASD.5 & AKP.9). Of the two types in each duration one was relatively resistant to blast. Differential spraying treatments (twice either at leaf infection or at neck infection stages or four times covering both the stages) were given to bring about variations in blast incidence in the experimental plots.

In the year 1959 only the two short duration varieties were included in the trial, as the amount of infection in the medium and late duration varieties were generally low and they did not respond to differential sprayings.

At the time of harvest the neck infection was estimated in samples and the yield of the plots determined. The correlation between neck infection and the loss caused by the same was estimated by the regression technique.

There was appreciable amount of neck infection only in the early varieties (Co.13 & T.6522). It was found that for every increase in neck infection by one per cent, there was a loss of nearly 0.98 per cent in yield in the susceptible variety, Co.13, while in the resistant variety the loss was only 0.46 per cent for one per cent increase in neck infection.

4. Studies on blast disease forecasting :

In the year 1959 the susceptible variety Co.13 was planted at four different dates viz., 7th, 14th, 24th and 31st of August during the main crop season. It was observed that leaf infection first appeared in the second and third plantings on the 24th September, and after a week later in the first and

fourth plantings. Infection spread quickly (within a week) in case of plants transplanted on 14th and 24th of August and in about two weeks in case of first and fourth plantings.

The incidence of neck infection was comparatively less in the first planting, whereas it was heavy in the remaining three plantings. In the year 1960, when the experiment was repeated, no incidence of blast infection could be detected in the plants.

5. Soil microbiological studies with bacterial inoculation :

During 1959, Azotobacter counts were made in field soils to which the seeds of rice inoculated with the bacteria were sown. Some relationship could be seen between the fertility as judged by yields of grain and the counts. During the current year a pot experiment was also conducted in addition.

In the pot experiment, seeds of PTB.10, a short duration variety, were soaked in "Azotobacterin" in water for about 24 hours and 72 hours and sown in pots of 14" diameter at the rate of three seeds per pot. Untreated seeds were sown as control. Ammonium sulphate, Superphosphate and Potash were added in different combinations as detailed in Table LXVI below. There were three pots under each of the treatment. The grain weight and the number of ear-bearing tillers were recorded at the time of harvest. The data are presented in Table below.

From the data it might be seen that response in yield was obtained in the Azotobacterin treatments and was generally higher in the seeds maintained for 24 hours as compared to the one kept for 72 hours. Maximum response in yield was recorded in the Azotobacterin treatment which had received also Ammonium sulphate and Superphosphate. Addition of Potash had in all cases depressed the yield. Further work is in progress.

TABLE LXVI

Table showing the number of ear-bearing tillers and grain yield obtained with seeds treated with "Azotobacterin"

Soil amendment added	Seeds inoculated 24 hours prior to sowing		Seeds inoculated 72 hours prior to sowing		Uninoculated seed	
	Number of ear-bearing tillers	Weight of grains	Number of ear bearing tillers	Weight of grains	Number of ear-bearing tillers	Weight of grains
1	2	3	4	5	6	7
Ammonium sulphate 5.0 gms.	}	8.00	7.00	4.33	3.66	2.00
Superphosphate 3.2 gm.						
Potash 1.00 gm.						
Ammonium sulphate 5 gms	}	14.00	9.00	13.92	11.00	16.00
Superphosphate 3.2 gms.						
Superphosphate 3.2 gms. Potash 1.00	}	4.00	3.00	4.42	2.66	1.33
No fertilizer						
	6.00	5.58	5.66	7.42	4.33	2.08

6. New Reports of fungi and diseases on rice from India :

(a) Fungi—

On dead rice plants :

1. *Gibberella fujikuroi* (Wr.) Sawada-ascigerous stage.
2. *Gibberella Zeae* (Schw.) Petch-ascigerous stage.

On dead leaves of rice :

3. *Cochliobolus* sps.—ascigerous stage—new record in India.

(b) Diseases—

1. Leaf spot disease—caused by *Helicoceras oryzae*.—new record in India reported to cause leaf sheath rot in U.S.A.
2. “Black Sheath Rot” disease of rice caused by *Ophiobolus oryzinus* Sacc., new record in India.

Physiology

The plant physiologist of Central Rice Research Institute joined his duties in June 1960. Good part of the year under report was necessarily spent in organising a new laboratory, in which to initiate and operate various research projects on rice physiology.

The following experiments were undertaken during the *Kharif* season of 1960.

I. Physiology of salt resistance :

Two known salt resistant varieties viz., S.R. 26B and *Patnai* 23, were grown in glazed pots, with the variety T.90 (Salt-susceptible) as control. There were three treatments of salt (NaCl) irrigation, namely 0%, 0.2% and 0.4%. The entire experiment was again divided into two sets, one under frequent irrigation and the other under limited irrigation. The salt concentration of the growth medium was recorded in terms of electrical conductivity of the saturated soil extract (hereafter referred to as Ece). Observations were taken on height, tillers, and Ece at regular intervals. Panicle characters such as length of the panicle, sterility percentage and 1000 grain weight were recorded at harvest. The total nitrogen and chloride contents were determined for both grain and straw.

Initial observations.—As the percolation rate in each pot cannot be expected to be uniform, the Ece of soil extract was taken as an index of salinity status of the growth medium. The following preliminary observations were made:

(1) About 5" from the top gives the least conductivity (before addition of salt).

(2) Stagnation causes salinity to limit itself to upper ayer (1"—3"):

(3) The conductivity of soil extract should read approximately 3.5 and 7.0 mmhos. to indicate 0.2% and 0.4% NaCl in pot respectively.

(4) Since rice plants do not grow long sub-terranean roots it is desirable that the pots for salt resistant work should be well-drained; otherwise there will be considerable differences in salt response of plants growing in different pots with different drainage capacity.

Morphological observations.—Tip drying of leaves seemed to be the most pronounced and immediate symptom of salt toxicity. This was followed by reduction in the production of tillers. Plants affected by salinity seemed to be deeper green in colour than usual. This may very well be due to higher concentration of soluble nitrogen in the straw.

At maturity the most remarkable observation was that in T.90 under high salt concentration with frequent irrigation, the number of surviving tiller was reduced to one or two. The percentage sterility in grain was very high.

From the morphological observation we can say that SR.26B and *Patna* 23 withstand salt irrigation better than the susceptible variety T.90. The yield data and other morphological observations clearly indicate that frequent irrigation aggravates the toxic symptoms due to salinity when plants are grown in pots under green-house conditions. This can be explained by the fact that the roots of the pot-bound plant are constantly exposed to salinity when soil is saturated with water and the percolation and leaching are limited. Under limited irrigated conditions, however, the rate of percolation is enhanced thereby rendering the root zone less saline.

Statistical analysis of the data (Table LXVII) shows the following trends:—

The yield data show that there is no significance in the yield between frequently-irrigated and limitedly irrigated treatments.

The varieties and their interactions are significant. The varieties, *Patna*: 23 and SR. 26B are significantly superior to T.90 in salt tolerance.

The concentrations are also significant. There is a significant decrease in yield from control to high percentage of salt.

The varieties $\times$ concentration is significant. The varieties Patnai 23 and SR.26B can withstand higher concentration of salt with the least deleterious effects more than control T.90 can.

TABLE LXVII

Field data in gms./pot (i.e.) replication

Variety	Treatment	Non-Irrigated				Irrigated			
		1	2	3	Total	1	2	3	Total
SR.26B .	C	41.02	32.80	34.95	108.77	33.72	41.50	41.30	116.52
	0.2%	29.79	35.00	43.75	108.54	39.32	34.08	31.43	104.83
	0.4%	18.30	17.90	24.67	60.87	29.44	5.00	17.72	52.16
Patnai-23	C	46.00	16.95	42.79	105.74	40.60	45.73	34.62	120.95
	0.2%	44.01	36.20	45.46	125.67	48.30	20.32	35.08	103.70
	0.4%	30.57	38.80	10.36	79.73	0.21	0.30	28.55	29.06
T.90 .	C	38.95	23.59	43.26	105.80	48.49	19.80	40.82	109.11
	0.2%	4.92	35.60	39.95	80.47	0.80	0.50	16.70	18.00
	0.4%	26.13	33.62	5.45	65.20	0.25	0.20	0.30	0.75

TABLE LXVIII

	SR.26B	Patnai 23	T.90	Conc.
Control	225.29	226.69	214.91	666.89
0.2% NaCl.	213.37	229.37	98.47	541.21
0.4% NaCl.	113.03	108.79	65.95	287.77
Var.	551.69	564.85	379.33	

- (i) Varieties are significant at 0.1% level.
(ii) Concentrations are significant at 0.5% level.
(iii) Interaction $V \times C$ is significant at 0.5% level.

TABLE LXIX

Data on total Nitrogen and Chloride content in straw (with comparative yield)

	Irrigated						Non-Irrigated					
	Control		0.2%		0.4% salt		Control		0.2%		0.4%	
	Yield		Yield		Yield		Yield		Yield		Yield	
I	2	3	4	5	6	7	8	9	10	11	12	13
<i>Chloride---</i>												
T. 90	0.962	109.11	1.291	18.00	1.547	0.75	0.860	105.80	1.122	80.47	1.695	65.20
SR. 26B	1.204	116.52	..	104.83	1.918	52.16	0.899	108.77	1.238	108.54	2.971	60.87
Patnai-23	0.844	120.95	..	103.70	..	29.06	0.950	105.74	2.625	125.67	2.741	79.73
<i>Nitrogen---</i>												
T. 90	0.78	109.11	1.00	18.00	1.42	0.75	0.79	105.80	0.78	80.47	0.75	65.20
SR. 26B	0.43	116.52	..	104.83	0.60	52.16	0.46	108.77	0.51	108.54	0.42	60.87
Patnai-23	0.41	120.95	..	103.70	..	29.06	0.39	105.74	0.42	125.67	0.49	79.73

TABLE LXX

Data on total Nitrogen and chloride (with comparative yield) in the grain

	Irrigated						Non-Irrigated					
	Control		0.2%		0.4%		Control		0.2%		0.4%	
	Yield		Yield		Yield		Yield		Yield		Yield	
1	2	3	4	5	6	7	8	9	10	11	12	13
Chloride—												
T. 90	0.152	109.11	0.176	18.00	..	0.75	0.136	105.80	0.156	80.47	0.149	65.20
SR. 26B	0.149	116.52	0.149	104.83	0.152	52.16	0.146	108.77	0.152	108.54	0.166	60.87
Pa nai 23	0.139	120.95	0.136	103.70	..	29.06	0.142	105.74	0.139	125.67	0.146	79.73
Nitrogen—												
T. 90	0.925	109.11	0.955	18.00	1.28	0.75	0.866	105.80	0.912	80.47	0.993	65.20
SR. 26B	0.943	116.52	0.979	104.83	0.906	52.16	0.995	108.77	0.902	108.54	1.009	60.87
Palnai-23	0.962	120.95	1.29	103.70	1.124	29.06	0.89	105.74	0.969	125.67	1.018	79.73

Discussion.—From the preliminary observations the total Nitrogen of straw and grain does not seem to be affected by the salinity of the growth medium.

The chloride percentage of the straw, however, depends on the salt treatment the plant has been subjected to. It is found to vary from approximately 0.84% in the control to approx. 3.0% in the plants receiving highest concentration. The concentration of the chloride in the straw, nevertheless, does not indicate the degree of adverse Physiological condition the plant had to resist. For instance, in the limited irrigation series, the variety Patnai 23 has recorded 0.950, 2.625 and 2.741 percentage of chloride in the control, 0.2% and 0.4% salt treatments respectively, although the respective total yields are 105.74, 125.67 and 79.73 gms. Similar observations are made in SR.26B under limited irrigation, where total grain yields both control and 0.2% salt treatment are 108.77 and 108.54 gms. respectively, whereas the respective chloride percentages are 0.899 and 1.238. These observations suggest the possible presence of some intrinsic system of ion antagonism in the salt resistant varieties. In other words, these varieties cannot only withstand excess chloride but also accommodate it without any harmful effect.

II. Upland varietal Trial :

Fourteen upland varieties were tried for their yield performance in 4 replications under upland and non-irrigated conditions (exclusively under rainfed condition). The growth of the crop was uniform and luxuriant. The following observations were taken :

- (1) height and tiller
- (2) yield in lb. per acre and in Kgm./hectre.
- (3) mean length of the panicle
- (4) sterility percentage
- (5) 1000 grain weight.

TABLE LXXI

The results are presented herewith:

Sl. No.	Variety	Yield in lb./acre	Yield in Kgm./hec.	Mean length of panicle	Sterility percentage	1000 grain weight	Ht. at peak tillering stage	Titter at peak tillering stage
1	2	3	4	5	6	7	8	9
1	W. 999	1238	1387	22.13	26.3	24.79	78.4	5.08
2	W. 742	2363	2467	29.12	55.5	30.59	78.1	4.00
3	T. 657	1854	2076	26.0	39.6	22.69	82.15	4.98
4	JBS. 771	2092	2343	26.12	37.7	25.7	72.4	5.30
5	Ac. 4	1901	2130	24.0	13.01	22.79	78.97	4.53
6	PTB. 10	1635	1831	25.4	17.50	26.58	83.2	4.63
7	Ac. 3902	1716	1922	21.75	29.50	24.65	77.9	5.15
8	W. 503	1303	1459	27.1	68.83	22.42	69.9	4.83
9	B. 76—116	2457	2752	27.4	37.9	23.49	74.9	4.28
10	Ac. 486	1227	1374	25.55	52.15	29.65	75.00	4.05
11	JBS. 1009	1476	1653	23.3	34.8	14.74	62.00	4.38
12	JBS. 598	1892	2119	26.62	14.4	23.08	62.60	4.28
13	JBS. 782	2111	2364	26.8	36.7	23.20	76.90	6.30
14	JBS. 979 (late)	964	1080	22.1	25.96	24.35	79.20	4.08

Inference.—JBS. 979 (a late variety) gave the minimum yield of 964 lb./acre. All the varieties, except W.503 and JBS.1009, are significantly superior to W.979. The highest yielder was B.76-116 (Control), which yielded 2457 lb./acre. Four varieties, namely B.76-116, W.742, JBS.771 and JBS.782, yielded more than 2000 pounds per acre.

It is obvious that the best upland variety will have certain drought resistant quality. Therefore, this trial which will be repeated next season has some far reaching implications.

III. Foliar spray of vitamins :

Experiment.—The effect of Vitamins (foliar spray) on the growth and yield of rice plant.

Details of the expt.—Variety=T.90

No. of vitamins =4 (a) Vit. B₁
 (b) Vit. B₂
 (c) Vit. B₆
 (d) Vit. C

No. of treatments =4 (a) 0 ppm.
 (b) 5 ppm.
 (c) 10 ppm.
 (d) 20 ppm.

Date of sowing — 8-7-60

No. of pots per each treatment=3.

Japanese workers did some work on the effect of Vitamin C in relation to rice plants. Ministry of Food and Agriculture, Govt. of India suggested, that similar work should be taken up at the C.R.R.I. It was considered proper to include a number of other Vitamins along with Vit. C. Foliar spray of different concentration of vitamins was done at three different stages of entire life cycle of the plants: (a) early tillering, (b) late tillering, and (c) boot leaf. At the flowering stage it was noted that Vitamin C seemed to have induced some earliness in flowering. At this stage there was some significant increase in growth in the treated plants as compared to untreated ones, although this difference in growth almost disappeared later on.

TABLE LXXII
 Yield data (in gms.)

Conc./Vit.	0 ppm.	5 ppm.	10 ppm.	20 ppm.
Vit. B ₁	93.41	72.31	90.53	99.20
Vit. B ₂	78.10	46.72	93.60	104.56
Vit. B ₆	108.84	75.82	121.58	78.77
Vit. C	66.85	67.74	117.93	71.52

From the previous table it is to be noted that there are some variations in the total yields under different treatments. Since the No. of replications was not sufficient no statistical analysis was done. In view of the results obtained it is, however, very possible that Vit. C at certain optimum concentration is beneficial to growth and yield of rice. This experiment will be repeated next season with particular emphasis on Vitamin C.

Statistics

In addition to giving assistance to all the research division in layouts, analysis of data and interpretation of results, the division undertook the following studies during this period.

I. Efficiency of confounded design :

Gain in precision due to confounding was worked out for a 2^6 factorial experiment in a single replicate to study the efficiency of different green manures with and without inorganic fertilizer.

The results of the analysis pooled for 4 years (54-58) showed that the gain in precision was about 13 per cent over that if the experiment were conducted in a randomised block design.

II. Correlation studies :

Intra varietal correlation studies were made on 11 medium duration varieties. The characters studied were yield of grains (gm.) of a single plant length of the panicle (cms.), number of effective tillers per plant and height of the plant. The varieties represented FR.43 B, T. 588, F.R. 13 A., CRH 15, T.1879, *Basumati*, SLO.6, T.1233, R.11 *Dubraj*, T.412 & T. 1145. Simple, partial and multiple correlation coefficients were computed.

It was observed from the simple correlations that the yield and number of effective tillers per plant were highly correlated while the length of the panicle and the effective tillers the least. The pooled estimate of the correlation coefficients in these cases were 0.8041 and 0.2496 respectively. The partial correlations revealed that the coefficient between the yield and the number of effective tillers was the highest while that of the yield and height of the plant was the lowest. The pooled estimates worked out respectively to 0.8210 and 0.1684. The multiple correlation coefficient recorded the highest value in case of variety T.1233 and lowest for CRH.15. The multiple linear regression equations in these two cases were as follows :

$$T.1233 : Y = 2.1608 X_1 + 1.6805 X_2 + 0.0352 X_3 - 46.65$$

$$CRH.15 : Y = 0.0977 X_1 + 0.6603 X_2 + 0.0491 X_3 - 5.69$$

Where, Y = expected yield of grain in gms.

X_1 = length of earhead in cms.

X_2 = No. of effective tillers per plant.

X_3 = height of plant in cms.

III. Response curves :

Quadratic response curves were fitted to the yield data on the nitrogen doses, of Ammonium Sulphate and Compost experiment pooled for ten years. Nitrogen was applied at 0, 20, 40, 60 and 80 lbs. N. per acre as Ammonium sulphate and compost at 0 and 100 mds. per acre every year. The equations were as follows:

$$\text{No Compost : } Y = 1870.116 + 25.1234 X - 0.2341 X^2$$

$$\text{Compost : } Y = 2342.544 + 15.5406 X - 0.2623 X^2$$

Where X represents the dose and Y the yield in lbs./acre.

The estimated maximum yields were obtained with 54 lbs. of N per acre in the absence of compost and 30 lbs. N per acre in the presence of compost as against 54 lbs. and 32 lbs. per acre respectively obtained by pooling up 8 years' data.

IV. Biometrical studies :

(a) *Genetic variability in F_3 and F_4 generations.*—Genetic variability of some plant characters such as single plant yield, ear-bearing tillers, total tillers, height of the plant, 500 grain weight and the number of grains per panicle was worked out in the said filial generations with a view to find out the trend of genetic variation in successive generations and to know in which generation the genetic variance became negligible.

It was observed that the genetic variance ranged from 8—27% and 6—31% amongst the various characters in F_3 and F_4 generations respectively. Amongst the various characters under study the highest genetic variation was recorded by yield and least by plant height. Only height showed a drop in genetic variance from F_3 generation to F_4 .

(b) *Linkage studies.*—Following Haldane's method of minimum discrepancy, as many as 300 formulae were developed for the estimation of linkage in F_2 . The ratios commonly occurring are :

Monogenic : 3:1

Digenic : 9:7, 15:1, 3:13.

Trigenic : 27:37, 63:1, 9:55, 45:19, 49:15, 54:10.

Tetragenic : 117:139, 162:94, 81:175, 27:229, 189:67.

All possible combinations of the ratios were considered in the joint segregation. Cases involving inhibitory genes were particularly taken into account and alternative formulae were developed wherever such genes were involved. Further work on this is continued.

V. Field trial :

In order to study the positional effect of varieties, an experiment was laid out in field in the main season of 1960. Four varieties viz., T.141, T.412, GEB.24 and T.1242 were taken, the former two belonging to the medium duration and the latter two to the late duration group. The system of planting was as follows :

- (i) the varieties as such,
- (ii) each variety followed by another in alternate rows, and
- (iii) each variety followed by the other after every third row.

There were altogether 16 treatment combinations. Planting was done in lines with one foot spacing between rows and nine inches spacing between the plants.

Each treatment consisted of 12 lines and each line contained 10 plants. One plant in each line was selected at random before harvest and the yield and the other yield attributes were observed on it.

The statistical analysis of the yield data showed that the differences between the treatment means were highly significant. It was observed that, in general, the varieties planted in alternate rows gave better result than those planted after every third row.

Farm

I. Seed Multiplication :

On an average about 125 acres was under cultivation every year, out of which an area of about 50 acres was under experiments and the rest under seed multiplication of different improved strains of paddy. The production of seed paddy was about 1000 mds. every year and 80% of this seed was supplied to the Orissa Agricultural Department for their seed farms or registered seed growers.

II. Maximum Potential Experiment :

This permanent experiment is designed to find out how far the yield of paddy could be stepped up by following the improved methods of cultivation year after year, in the same site. The plots covering an area of 4.93 acres were sown with daincha after an application of 100 lbs. superphosphate in the plough furrows, and the green manure crop so raised was ploughed under, when about 6 to 7 weeks old (5 to 6000 lbs. per acre) by the third week of July. Puddling of the land was commenced by the end of July and 50 lbs. Ammonium Sulphate per acre applied in the plots at the time of final puddling. Seedlings of the most popular strains of paddy, *viz.*— T.1242 and Bam.9 were planted in the first week of August during alternate years with a spacing of 12" × 6". A second dose of Ammonium Sulphate at 50 lbs. per acre was applied by the first week of October. A grain yield of 3068 K.gm./ha in 1958, 1880 K.gm./ha in 1959 and 3914 K.gm./ha in 1960 were obtained, whereas the average yield obtained during the previous years was 3085 K.gm./ha. The unusual low yield during 1959 was due to the non-availability of irrigation water at the time of flowering, which resulted in the poor setting of the grains.

III. Yield Trials :

(i) Jhelli Selections trial :

Nine promising selections made from *Jhelli*, a popular superfine variety, during 1958 were tried against recommended types of the same duration, *viz.*,—T.90, T.1242, Bam.9 and J.192 Bk for two years. The selections J.192/11 and J.192/12 were found to be better than J.192 Bk during both the years, though the coarse grained types T.1242 and Bam. 9 were definitely superior to them by about 8%.

TABLE LXXXIII

Variety	J.175/1	J.175/2	J.175/4	J.192/7	J.192/8	J.192/10	J.192/11	J.192/12	J.192	T.90	T.1242	Bam.9
verage yield in K.gm./ha (1959 & 1960).	168	1810	1831	1776	1744	1878	2028	2028	1898	1796	2199	2157
% over Control.	88.9	95.4	96.5	93.6	91.9	98.9	106.8	106.8	100.0	94.6	115.9	113.6
C.D. in K.gm. per ha at 5%.	129											

(ii) *GEB. 24 Selection Trials:*

Ten promising selections made from GEB. 24 during 1958, were tried against GEB. 24 Bk. and J. 192 for two years. Selections GEB. 24/13, GEB. 24/16 and GEB. 24/47 were found to give increased yields by about 14% over the control, but were inferior to J. 192.

TABLE LXXIV

[illegible]

(iii) *Varietal trial :*

Seven improved popular strains with a duration ranging from 150 to 165 days were tried both under medium and low land conditions during 1958. T. 1242 was found to be better than the rest in the former group giving an yield of 2922 K.gm./ha when compared to the strain T. 141 suited for such conditions. The yield of control was 2429 K.gm./ha. The trial in the low land could not give any idea as the experimental strips were badly insect attacked.

(iv) *Effect of planting on different dates on the yield of paddy :*

Four popular strains, T. 141, J. 192, Bam. 9 and T. 1242 were planted on seven different dates during 1958 and 1959 at 10 days intervals commencing from the 28th July, the last date of planting being 26th September. The results confirmed the findings of the previous year, *viz.*, that higher yields were obtained with the July and 8th August plantings. The yields were found to decrease in a linear fashion in all plantings beyond 8th August, except in the case of T. 141, where the plantings done up to the last week of August gave as much as 80% of the yield of the control.

TABLE LXXV
Average yield in Kg/Ha (1958 and 1959)

Variety	Planted on						C. D. in K. gm. per ha. at 5%
	28/7	7/8	17/8	27/8	6/9	16/9	26/9
T. 141	2909 (100.0)	2876 (98.8)	2324 (79.9)	2420 (83.2)	1820 (62.6)	1326 (45.6)	1033 (37.2)
J. 192	2673 (100.0)	2428 (90.6)	1838 (68.8)	2066 (75.0)	1877 (70.3)	1494 (55.9)	1421 (53.1)
T. 1242	3022 (100.0)	2677 (88.6)	1906 (63.0)	1886 (62.3)	1487 (49.2)	1196 (39.6)	843 (27.8)
Bam. 9	2815 (100.0)	2586 (89.8)	2028 (72.0)	1533 (54.5)	1265 (45.0)	1066 (37.9)	722 (25.7)

(v) *Effect of different interculturing practices on the yield of low land rice :*

The differences in yield obtained during 1958 and 1959 were found to be not significant under the different conditions, as in the previous years.

Treatment	Average yield in K. gm./Ha. (1958 and 1959)	% over control
Interculturing a crop planted in lines 12" × 6" with		
1. Country Plough	1958	102.1
2. Japanese weeder	1981	103.4
3. Hand weeding	1887	98.4
4. No weeding (control)	1917	100.0

(vi) *Spacing Trials :*

(a) With a view to obtain maximum grain per unit area by increasing the number of tillers, length of ear-heads and the number of grains per ear-head, the optimum spacing requirement was studied in combination with different cultural methods in two separate trials.

(i) In one trial the treatments given were the following:

1. Planting in lines 2'6" apart and 6" in the lines with two seedling per hole.
2. Same as in treatment 1, but the spacing of 2'6" filled up by two additional lines of 10", planted a month later with seedlings obtained from a double transplanted bed, with two seedlings per hole.
3. Planting in lines 10" apart and 6" in the line with two seedlings per hole.

TABLE LXXXVI

The yields obtained during 1959 and 1960 are as follows :

Treatments	1959			1960		
	T ₁	T ₂	T ₃	T ₁	T ₂	T ₃
Yield in K. gm./ha	2024	2425	2775	1173	1781	2060
% over control	73.6	87.4	100.0	57.0	86.4	100.0
C. D. in K. gm. per hectare at 5%	392	..	..	128	..	..

A careful examination of the table shows that the spacing of 2'6" in T₁ has proved to be quite un-economical. In spite of the increases obtained in the tiller production, length of ear-head, number of grains per ear-head etc., the cumulative effects of these increases failed to bring about the maximum yield of grain per unit area in the treatment T₁.

(b) In another trial, peripheral planting was compared against normal planting during 1959 and 1960. The treatments were:

1. Planting in lines 9" apart with 12" between the lines. At each 9" spacing, one plant was planted, and 2" away from this plant, on all the four sides, one plant was planted.
2. Planting in lines 9" apart with 12" between lines with five seedlings per hole.

The yield data given below revealed that there was significant difference between the treatments:

TABLE LXXVII
(Average for 1959 and 1960)

Treatments	T ₁	T ₂
Yield in K _g .gm./ha	1760	1546
% over control	113.8	100.0
C.D. per hectare at 5%	101 Kgm.	

(c) *Replanting with closer spacings.*—This trial was laid out during 1960. The normal planting of 12"×6" was compared against a new type of planting in which, the plant, just before completing its tillering phase, was uprooted, split into three (each split having 4 to 5 tillers) and one split planted into the same hole and the other two, 4" on either side of it. The treatments were duly randomised and replicated. The new treatment was given to achieve the following objectives: (1) to stop the further growth of the crop; (2) to induce the plants to produce new roots and more tillers; (3) to induce absorption of more nutrients from the soil due to the increase in the density of the population; and (4) to enable the plants to utilise the nutrients so absorbed for increased grain production and to reduce the straw/grain ratio. One of the popular strains T. 90 was used for this experiment.

	Treated plot 12" X 6" converted into 6" X 4" with split seedlings	Control 12" X 6" planting
Yield in K _g .gm./Ha.	4007	3652
% over control	109.7	100.0
C.D. per hectare at 5%	253 K _g .gm.	(111)

The treated plots have given an increased yield by 9.7%. The plants in the treated plots were erect and comparatively less tall when compared to the control even at the time of harvest.

(d) *Interplants by trials.*---In another trial conducted during 1960 the treatments were as follows:—

1. In a normal plot planted under $12'' \times 6''$ spacing during early August, the seedlings were uprooted in mid-September split into three and one split replanted into the same hole and the other two, $4''$ apart on either side of it giving a spacing of $6'' \times 4''$.

2. Same as treatment 1, but the spacing of $6'' \times 4''$ filled up by introducing seedlings from double transplanted seedbeds and planting them $4''$ apart on either side of the plant in mid September.

3. Normal planting of $12'' \times 6''$ (Control).

The variety used was Bam. 9

Treatments	1	2	3
Yield in K.gm. /ha.	3714	3039	3222
% over control	115.0	94.3	100.0
C.D. per hectare at 5%	251 K.gm.		

The treatment 2 and 3 were at par and the treatment 1 was definitely found to be superior to the rest.

(vii) *Comparison of the effects of different tillage operations on the yield of paddy:*

The yields of grain obtained from different plots prepared by tractor or bullock power, both under dibbled and transplanted conditions, were compared during 1960. It was found that dibbling paddy by the third week of June yielded as much as the paddy transplanted by the 2nd week of August, irrespective of the tillage operations being done by tractor or bullocks. The main draw back was the slow progress of the work when done by bullock power. The change over to mechanised cultivation wherever feasible, was found to be advantageous to complete the operations in time without sacrificing the yield.

	Tractor power		Bullock power	
	Dibbled plo	Planted plot	Dibbled plot	Planted plot
Mean yield in K.gms. per hectare	2890	2867	2858	3057

(viii) *Second crop:*

During 1958, a total area of about 30 acres was under the 2nd crop of paddy with the popular strain MTU. 15, GEB. 24, T. 6522 and PTB.10. An average grain yield of 16 mds/ac i.e., 1456 K.gm./ha was obtained from this crop. One of the newly evolved blast resistant cultures (F₁₀) gave an acre yield of 3281 lbs. i.e., 3642 K.gm./ha.

As the local govt. did not ensure water supply in the main irrigation canal beyond January, no bulk crop of paddy could be taken up during 1959 and 1960. However the sowing of rabi crops as mung, biri, cowpea etc. was completed by the end of October during these years in an area of about 30 acres.

(ix) *Intensive cultivation centre:*

(1) Seventeen simple manurial trials were conducted during the Kharif season with the strains T. 1242 and BAM. 9, and four during the rabi season with the strain T. 6522, in the cultivator's fields during 1958. No significant differences in yields were noticed in the Kharif crops, but an increased grain yield of 360 lb. per acre was obtained from the rabi crop for an addition of 30 lb. N/acre. There was no response for the addition of P_2O_5 and/or K_2O .

TABLE LXXVIII

Yield in lb. per acre

Treatment*	Kharif Season			Rabi Season		
	Bam. 9	% over control	T. 1242	% over control	T. 6522	% over control
N1 . . .	2513.6	111.8	2184.0	96.5	1518.8	130.9
N1P1 . . .	2128.0	94.7	2315.2	102.2	1580.0	136.4
N2P2 . . .	2174.0	96.7	2294.4	101.4	1643.0	141.9
N1 P1 K1 . . .	2316.0	103.0	2377.6	105.0	1599.5	138.0
N2 P2 K2 . . .	2390.0	106.4	2331.2	103.0	1613.3	139.2
Control (no manure)	2248.0	100.0	2264.0	100.0	1159.2	100.0

(*) N1=30 lb. N/acre, P1=30 lb. P_2O_5 /acre, K1=30 lb. K_2O /acre,
N2=45 lb. N/acre, P2=45 lb. P_2O_5 /acre, K2=60 lb. K_2O /acre.

These experiments were also duplicated in the Institute farm lands and it was found that in the case of the strain T. 141 an increased grain yield of 185 lb./acre was obtained by the addition of 30 lb. N/ac. In other strains, the treatment differences were not significant.

(2) Growing of dhaincha and S. speciosa on a large scale for manuring rice crop and also for planting them along the field bunds for seed purposes was popularised in this centre.

(x) *Training:*

The trainees were given a course of lectures in farm Management, cost of cultivation and cost of production of paddy etc. during 1960.

Fifty three enquiries received from different parts of the country during the period 1958 to 1960 mostly on the suitability of the different improved strains of paddy for different locations, were attended to.

Agricultural Engineering

I. Investigations, trials and Research work on hand tools and implements:

(a) Land preparation implements:

(i) Investigations are in progress to assess the suitability of Orissa Duck foot plough and other improved implements for wet land cultivation including puddling operations.

(b) Seedling and Planting Equipment:

(i) Field experiments were conducted to compare the efficacy of direct sowing as compared to transplanting of paddy seedlings on field plots prepared with bullock drawn equipment as well as field plots worked by mechanised equipment. Encouraging results have been observed in low landplots and data collected is being compiled.

(ii) Preliminary investigations are in progress for the development of a seeder for direct sowing in puddle.

(iii) *Hand Transplanter*—Wooden Hand Transplanters fabricated at the Institute were put to field trials. Different designs of the planting mechanisms were developed to improve their performance and efficiency. Observations were also made to study the time/labour requirements for transplanting one acre.

The best results achieved so far were observed with 6 row, 6" spacing. Plant efficiency obtained was 87% and 87 man hours were spent in transplanting one acre resulting in 37% saving in labour requirements. Work on this tool will be continued in the next planting season.

(iv) *Transplanting machine*—A bullock drawn transplanting machine was got fabricated on the pattern of the transplanting machine displayed at the Chinese pavillion during the World Agricultural Fair held in New Delhi. Efforts made to improve the implement for getting the functional performance have not been successful so far.

(c) Harvesting tools and implements:

(i) Field trials are in progress to assess the suitability of a new type of hand harvester received from Japan through the extension Directorate in the Ministry of Food and Agriculture.

(ii) Different designs of hand harvesters on the same principle have been developed and fabricated at the Institute. Field trials are in progress to improve their performance and efficiency.

(iii) A bullock driven power operated harvesting machine received in the past under Colombo plan was put to working order and tried in the field. This machine was capable of harvesting only the heads from the standing crop, quality of grains harvested were not considered fit for storage and as such comprehensive trials were not undertaken.

(iv) Encouraging results were achieved to study the scope of grain harvesting machines on paddy crop. Field trials were conducted with Gotz Reaper of Austrian make and Vilking Reaper of Danish make. They were found economical and efficient on standing crop. Losses due to shedding were low, cost of working would depend upon the size of holdings and the annual usage.

II. Mechanisation of Rice cultivation :

(i) Field operations for cultivation work are carried out by mechanised equipment. Observations are in progress for the improvements in paddy disc harrows, some of the observations made regarding the wear and tear noticed while operating the implement used for puddling were brought to the notice of the manufactures.

(ii) Field trials were carried out to study the scope of mechanisation on small holdings and asses the suitability of Land Master Tropical Tiller under wet land conditions. These trials were sponsored by I.A.R.I., New Delhi in different States and Central institutes.

III. Workshop :

(i) All routine maintenance and day to day repairs on Farm Tractors Agrimachinery, hand tools, implements besides transport vehicles were carried out in the workshop.

(ii) Installation of workshop plant and equipment received under T. C. M. aid was completed. Good progress of work was made in wood working section. Further development of workshop facilities besides the strengthening of workshop personnel is in progress.

IV. General :

(i) Papers were contributed at the Agricultural Engineering symposium and 2nd conference on production, distribution and popularisation of improved Agricultural implements held at Kharagpur.

(ii) An article on "Harvesting trials with Reapers" was published in the "Rice News Teller" Oct.—Dec. issue.

(iii) A tour was undertaken to study the Research activities on Rice implements in the States of U. P. and Bihar.

Training

Two post-graduate students of the Indian Agricultural Research Institute Associateship course specialising in rice Agronomy joined the Institute for doing the thesis part of the course and worked on the following research problems.

1. Effect of continuous application of Ammonium sulphate in conjunction with compost on the yield of rice and fertility of the soil.

2. Effect of continuous application of Ammonium sulphate with lime and compost on yield and other agronomic characters of rice.

Two post graduate students from I. A. R. I. specialising in rice joined the Botany Division in the year 1958 and the results of their research problems were submitted by them in the form of thesis to I. A. R. I. as partial fulfilment for the degree of Associate I. A. R. I.

1. Mr. K. N. Iyer.—“Genetics of anthocyanin pigmentation, awning and presence or absence of auricle, ligule and junctura and interrelation of genes governing pigmentation”.

2. Mr. S. Kurup.—“Possibilities of breeding rice strains suitable for two different levels of soil fertility from the F_5 generation of *japonica* $\times$ *indica* hybrids”. Thesis submitted to I. A. R. I. as partial fulfilment for the degree of Associate I. A. R. I.

The National Training Course intended to make available to the trainees from different States in India the latest information in the different aspects of rice breeding, genetics, plant protection measures and cultural practices was started in July 1960. Twelve trainees from eight different States attended the course which terminated on the 15th December 1961. Practical classes were also held in the different subjects and the trainees were provided with all facilities to get themselves acquainted with the material in the field as well as with the work now being carried out at the Institute.

Sri P. V. Pailey, Lecturer in Mycology Agricultural College, Vellayan Kerala, underwent training for three months on rice disease investigation with special reference to artificial infection technique.

Fifteen theoretical and fifteen practical classes in Statistics were organised during the year under report to impart training to the student under the National Training Course for rice breeders.

The trainees were given a course of lectures on farm Management, cost of cultivation and cost of production of paddy etc. during 1960.

Fifty three enquiries received from different parts of the country, during the period 1958 to 1960 mostly on the suitability of the different improved strains of paddy for different locations, were attended to.

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PROGRAMME OF WORK FOR 1961

Agronomy Division

1. Study of the yield performance of different duration varieties.
2. Trial of varieties for late *aman* planting and double cropping.
3. To determine the suitability of various crops for growing in rotation with rice.
4. Developmental studies.
5. Effect of seed treatment with bacterial culture on the yield of rice.
6. Study of the efficiency of various herbicides for control of weeds in rice fields and determining the optimum dosage and time of their application.
7. Study of the relative efficiency of various nitrogenous fertilizers.
8. Determination of optimum dose, time and method of application of nitrogenous fertilizers and their residual and cumulative effect on soil fertility.
9. Response of different duration varieties to various spacings, manuring and their times of application.
10. Determination of water-requirement of rice crop.

Botany Division

I. Maintenance and study of Genetic stocks.

II. Agro-genetical studies—

- (1) Breeding for high yield and response to heavy soil fertility.
- (2) Preliminary yield trial of introductions.
- (3) Maintenance of early maturing high yielding cultures.
- (4) Breeding for high yield combined with quality.
- (5) Improving yield of *Basmati* rices.
- (6) Breeding for disease resistance—in collaboration with the Mycologist.
- (7) Breeding for profuse tillering and high yield.
- (8) Breeding for yield and low-photosensitivity.
- (9) Practical utilisation of heterosis.

III. Fundamental Genetics—

- (1) Inheritance of anthocyanin pigmentation in different plant parts.
- (2) Inheritance of protein content.
- (3) Inheritance of cooking quality.
- (4) Inheritance of endosperm nature and its association with other characters.
- (5) Studies on linkage relationship.
- (6) Studies on single tiller progeny segregation.
- (7) Cytoplasmic inheritance.
- (8) Study of irradiated material.
- (9) Studies on the effect of gibberellic acid on dwarfs and other types.
- (10) Genetics of fertilizer response—in collaboration with the Agricultural chemist.

IV. Biometrical Genetics.

V. Studies on the efficiency of different breeding techniques.

VI. Awning behaviour in rice.

VII. Study of lodging and breeding for non-lodging habit—

- (1) Testing of varieties for resistance to lodging.
- (2) Cultural practices in relation to lodging.
- (3) Studies on the response of varieties to manuring.
- (4) Breeding for non-lodging habit—study of different generations.
- (5) Morphological and anatomical studies on lodging and non-lodging types.

VIII. Gene Assemblage.

IX. Survey of the flora of *Oryza* species for useful genes.

X. Embryological and anatomical investigations.

XI. Collection and identification of rice weeds.

XII. Jeypore Botanical Survey—

(1) Maintenance of collection.

(2) Preliminary yield trials.

(3) Study of varieties with *japonica* type of grains.(4) Study of F_2 and F_3 generations.

XIII. Cytology of rice—

(1) Inter-sectional relationship of species.

(2) Studies on the origin of cultivated rices.

(3) Study on mutations.

(4) Study on chromosome variants.

(5) Maintenance of semi-sterile cultures, inter-specific hybrids and other types.

(6) Utilisation of *bulu* types.

XIV. Investigations on the utilisation of blue-green algae in rice field.

XV. Saline resistant rice research station, Canning town, West Bengal—

(1) Collection, maintenance and study of saline resistant rice varieties.

(2) Hybridization studies utilising saline resistant *fatua* types.

(3) Physiology of saline resistance.

(4) Study on the performance of green-manure crops at the research station.

Chemistry Division

1. Studies on Nitrogen transformation in Soil—Nitrogen fixation, Nitrogen losses and other related processes by tracer technique using No. 15.

2. Study of Phosphate dissolution and mobility under water logged soils.

3. Change of oxidation reduction potential in rice soils with degree of water lodging and its effect on the availability of the nutrients in soil.

4. Soil water plant relationship with respect to varying conditions of cultivation.

5. Study of rizosphere effect of paddy soils.

6. Role of Antibiotics in rice cultivation, storage, susceptibility to disease and in improving the nutritional quality of the grains.

Entomology Division

1. Studies on varietal reactions of rice to stem borers.
2. Insect resistance in rice with particular reference to gall fly and stem borers.
3. Efficacy of different methods of application of insecticides in controlling pests.
4. Estimation of losses due to hispa and gundhi bugs.
5. Studies on influence of macro-micro-climatic factors on the seasonal prevalence and incidence of gall fly, stem borers, gundhi bugs and hispa.
6. Studies on incidence of pests in relation to cultural and agronomic practices.
7. Studies on the nature of gall formation in rice.
8. Collection of indigenous parasites and predators of the more important pests, viz., stem borers, gall fly, gundhi bug, hispa and mealy bugs and investigation of possibilities for biological control of these pests.
9. Studies on seasonal abundance of pests with a view to forecasting their outbreaks.
10. Laboratory studies on (a) Toxicology of Insecticides (b) Bionomics of rice pests.
11. Fish-cum-rice culture.
12. Effect of spacing on incidence of pests.

Mycology Division

- I. Study and estimation of resistance to diseases in field of the collection of types under Genetic Stocks.

II. *Helminthosporium* disease :

- (i) Collection of isolates of *H. oryzae* from different parts of India and testing selected resistant varieties of C.R.R.I. with a mixture of isolates.
- (ii) Artificial infection tests on early types (2nd series. 111-125 days) of genetic stocks for selection of resistant types—
- (iii) Breeding resistant varieties by hybridization. (in collaboration with Botany Section).
- (iv) Studies on the nature of disease resistance of rice varieties— Effect of nutrition on disease expression—leaching of soil on incidence of disease; relation of K nutrition on incidence of disease.
- (v) Studies on collateral hosts.
- (vi) Co-ordinated helminthosporiose resistance trial in different rice growing states—8 state.
- (vii) Multiplication of resistant types.

III. Blast disease :

A. Artificial infection tests in seedling stage:—

- (i) Artificial infection tests on early-types—*i.e.* (2nd series 111-125 days) of genetic stocks for selection of resistant types.
- (ii) Testing of short duration varieties under World Genetic Stocks—
- (iii) Testing of varieties released from Central Rice Research Institute—
 - (1) Reaction of wild species & related species.
 - (2) Chromosome variants.
 - (3) Cobalt irradiated types.
 - (4) Coumarin treated mutant.
 - (5) Boak $\times$ Bonter selection.
 - (6) C.R.R.I.-1-6.
 - (7) Non-lodging strains.
 - (8) Jeypore collection-(extracts of *fatua* and cultivated types)—pots.
- (iv) Testing of varieties received from outside—
 - (1) Siamese types.
 - (2) Kerala varieties.
 - (3) Hyderabad varieties (*Indica* $\times$ *Japonica*).
 - (4) Kashmir types—pot.
 - (5) Bombay types &
 - (6) M.P. types.

B. Breeding of resistant varieties by hybridization and selection (in collaboration with Botany section).

C. Studies on collateral hosts.

D. Studies on nature of resistance of rice varieties—

- (i) Resistance to penetration & development of infection.
- (ii) Genetical studies on disease resistance in collaboration with Botany Section.

E. Control of blast by spraying—

- (i) with different fungicides
- (ii) low volume spraying *vs.* normal volume spraying using 'Aretan'
- (iii) with new fungicides.

- F. Studies on blast disease forecasting.
- G. Physiologic specialisation.
- H. Inoculation with mixture of isolates.
- I. Multiplication of resistant types.
- IV. Studies on new leaf drying disease of rice.
- V. Soil microbiological studies with bacterial inoculants.
- VI. Viability of culture in storage.
- VII. Studies on storage of rice and paddy (in collaboration with Entomology, Agronomy, Botany, Physiology and Chemistry).
- VIII. Isolation of antibiotic producing organisms from the soil.

Statistics Division

- 1. Field experiment on positional effect of varieties.
- 2. Further studies on the development of linkage formulae.
- 3. Studies on response curves.
- 4. Studies on crop weather relationship.

Farm Division

- 1. Multiplication of improved strains of paddy and maintenance of purity.
- 2. Maximisation of crop yield by following the recommended methods of cultivation.
- 3. Study on the cost of production of paddy under different patterns of cropping.
- 4. Study of the economics of growing paddy by drilling, dibbling and transplanting in the lands prepared by different implements.
- 5. To study the effect of tractor ploughing the low lying areas on the yield of transplanted rice and working out the economics of the same.
- 6. Study of the performances of the promising selections from GEB. 24 and J.192.
- 7. To study the effect of rotating paddy with sugarcane.
- 8. Extension work on improved methods of cultivation to the farmers in the Intensive Cultivation Centre.

TABLE LXXIV

Narrative financial accounts under revenue grant for inclusion in the Technical Report for the period from 1958 to 1960

Sub-head	1957-58		1958-59		1959-60		1960-61	
	Final grant	Actual expenditure	Final grant	Actual expenditure	Final grant	Actual expenditure	Final grant	Actual expenditure
1	2	3	4	5	6	7	8	9
<i>Main Institute :</i>	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
Pay of Officers	94,890	94,549	99,990	96,702	1,16,150	1,14,865	1,32,100	1,25,264
Pay of Establishment . .	83,120	82,925	1,02,490	1,01,042	1,07,970	1,06,544	2,36,250	1,73,227
Allowances & Honoraria etc. .	84,030	82,129	91,460	89,401	1,17,540	1,14,085	85,295	92,555
Other charges	2,00,700	1,68,935	2,08,300	1,90,001	2,72,700	2,34,463	3,55,000	2,53,496
Cost of Material and equipment under Colombo plan.	60	34	Nil	Nil	Nil	Nil	Nil	Nil
Other expenses	970	954	Nil	Nil	Nil	Nil	Nil	Nil
Cost of Material and equipment under T. C. A. programme.	13,728	13,067	50	33	109	109	Nil	Nil
Other expenses	3,000	1,664	8,700	13,278	194	917	10	10
TOTAL	4,80,498	4,44,257	5,10,990	4,90,457	6,14,663	5,70,983	8,08,655	6,44,552

Sub-head	1957-58		1958-59		1959-60		1960-61	
	Final grant	Actual expenditure	Final grant	Actual expenditure	Final grant	Actual expenditure	Final grant	Actual expenditure
I	2	3	4	5	6	7	8	9
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
I.C.A.R. Schemes :								
(a) Scheme for Botanical Survey and Collection of Breeding material.	17,400	17,712	14,500	13,577	19,600	19,567	Nil	Nil
(b) Scheme for further research on green manuring crops for paddy.	7,800	7,545	Nil	Nil	411	411	Nil	Nil
(c) Scheme for breeding paddy strain resistant to lodging.	14,170	13,748	14,600	14,638	14,850	14,682	17,230	15,534
(d) Scheme for Cytological, Anatomical and Embryological studies on rice etc.	Nil	Nil	Nil	Nil	4,650	4,642	9,300	10,000
(e) Scheme for Pilot Survey etc.	Nil	Nil	Nil	Nil	24,250	22,475	44,500	36,438
(f) Scheme for comparative efficiency on Ammonical and Nitrate fertilizer on paddy.	Nil	Nil	Nil	Nil	Nil	Nil	1,770	1,191
TOTAL I.C.A.R. SCHEMES	39,370	39,005	29,100	28,215	63,761	61,777	72,800	63,163

Sub-head	1957-58		1958-59		1959-60		1960-61	
	Final grant	Actual expenditure	Final grant	Actual expenditure	Final grant	Actual expenditure	Final grant	Actual expenditure
I	2	3	4	5	6	7	8	9
<i>Abstract :</i>								
Main Institute (Plan and Non-Plan)	Rs. 4,80,498	Rs. 4,44,257	Rs. 5,10,990	Rs. 4,90,457	Rs. 6,14,663	Rs. 5,70,983	Rs. 8,08,655	Rs. 6,44,552
I.C.A.R. Schemes.	39,370	39,005	29,100	28,215	63,761	61,777	72,800	63,163
GRAND TOTAL	5,19,868	4,83,262	5,40,090	5,18,672	6,78,424	6,32,760	8,81,455	7,07,715

STAFF

Director	R. H. Richharia, M Sc., Ph. D. (Cantab), F. B. S., F. R. S. (A).
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Agronomy Division

Agronomist	Moti V. Vachhani, B. Ag., Ph. D.
Research Officer in Agronomy	I. C. Mahapatra, B. Sc., Hons., (Ag.) Assoc. I. A. R. I.
Research Assistant	M. S. Choudhury, B. Sc., (Ag.) Assoc. I. A. R. I.
Research Assistant	M. V. Rao, B. Sc. (Ag.).
Research Assistant	G. B. Manna, M.Sc. (Ag.).

Agricultural Engineering Division

Agricultural Engineer	M. L. Taneja, B. Sc., (Agri. Engineering).
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Botany Division

Geneticist & Botanist	B. Misro, B. Sc. (Ag.) Assoc. I. A. R. I., M Sc., (Lond.).
Assistant Botanist	R. Seetharaman, M.Sc., Ph. D.
Research Assistant	C. N. Relwani, B. Sc., (Ag.).
Research Assistant	C. Gangadharan, M. Sc.
Research Assistant	N. K. Chau Patnaik, M. Sc.
Research Assistant	M. V. S. Sastry, M. Sc.
Research Assistant	V. A. Kulkarni, M. Sc.
Research Assistant	J. Rama Krishna Rao, M. Sc.
Research Assistant	Miss. Alakamanjari Das, M. Sc.
Research Assistant	Prasenjit Jee Jachuck, M. Sc.

Cytology Division

Cytologist	S. Sampath, M. A.
Research Assistant	D. V. Seshu, M. Sc.

Chemistry Division

Agricultural Chemist	Dr. C. T. Abichandani, M.Sc., Ph. D. (Up to 5-9-60).
Research Assistant	S. Patnaik, M.Sc.
Research Assistant	K. Jan-ki Ram, M. Sc.

Entomology Division

Entomologist	P. Israel, M. A., F. R. E. S.
Research Officer in Entomology	Y. S. Rao, M. Sc.
Research Assistant	V. Nageswar Rao, M. Sc.

Mycology Division

Mycologist	S. Y. Padmanabhan, B. Sc. (Hons.), M. A., Assoc., I.A.R.I.
Research Officer in Mycology	N. K. Chakrabarti, M. Sc., D. Phil.
Research Assistant	J. Veeraraghavan, M. Sc.
Research Assistant	G. H. Chandwani, B. Sc. (Ag.)

Plant Physiology Division

Plant Physiologist	S. K. Majumdar, M. Sc., Ph. D.
Research Assistant	K. S. Murty, M. Sc. (Ag.)
Research Assistant	Ch. Narasinga Rao, M. Sc.

Farm Division

Farm Superintendent	M. S. Pillai, B.A., B.Sc. (Ag.)
Research Assistant	N. A. Parasuram, B.Sc. (Ag.)

Statistics Division

Statistician	A. K. Ghosh, M.Sc.
Research Assistant	S. V. S. Prakasa Rao, M.Sc.

I. C. A. R. Scheme for Survey and Collection of Breeding Material from Jeypore Tract of Orissa State

Assistant Botanist	S. Govindaswamy, M.Sc., Ph.D.
Research Assistant	A. Krishna Murty, M.Sc.

I. C. A. R. Scheme for Breeding Paddy Strains Resistant to Lodging

Research Assistant	M. J. Balakrishna Rao, M. Sc.
Research Assistant	Miss Suprava Mohanty, M. Sc.

Sub-Station

Research Assistant	P. N. Sreedharan, M. Sc.
Research Assistant	T. E. Srinivasan, M. Sc.
Research Assistant	V. K. Muralidharan, M. Sc.

Pilot Survey Schemes

Field Officer	G. Veda Moorthy, M. A., Assoc. I. A. R. I.
Field Supervisor	K. V. S. R. Kameswar Rao, M. Sc.

Japonica × Indica Scheme

Assistant Botanist	R. K. Misra, M. Sc.
Assistant Botanist	B. K. Karibasappa, B. Sc. (Ag.), Assoc. I. A. R. I.



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